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# ENCYCLOPÆDIA METROPOLITANA;

OR,

## UNIVERSAL DICTIONARY OF KNOWLEDGE,

**On an Original Plan:**

COMPRISING THE TWOFOLD ADVANTAGE OF

A PHILOSOPHICAL AND AN ALPHABETICAL ARRANGEMENT,

*WITH APPROPRIATE ENGRAVINGS.*

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Botany.

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# ENCYCLOPÆDIA METROPOLITANA;

OR,

## UNIVERSAL DICTIONARY OF KNOWLEDGE.

**Second Division.**

## BOTANY.

Botany.

THE Science of BOTANY, (Βοτάνη, *herba*,) comprehending the knowledge of the vegetable creation, is conveniently divided into two branches, mutually illustrating each other.

1. The Anatomy and Physiology of plants, comprising their structure, component principles, modes of propagation and growth, their diseases and duration.

2. Their Natural History, comprising Terminology, or an explanation of the characteristic terms by which Botanists have universally agreed to distinguish the varieties of structure of the various organs; Classification, or method of arrangement; and Nomenclature, or system of naming each individual.

When investigating the Anatomy of plants, the first objects that attract our attention are the external or compound organs, consisting of the root; the herb, comprising the trunk, branches, and leaves; and the fructification, or flower, fruit, seed vessel, and seeds.

The *root* is that part of the plant by which it is attached to the soil or substance on which it vegetates, and is the principal organ for the supply of nourishment. A root usually consists of two parts, the *caudex descendens*, or descending stem, on the top of which is the crown or collar, separating it from the trunk, or ascending stem; and the *radiculæ* or fibres, which are considered the true root, or part which extracts from the soil the nourishment necessary to the growth of the plant. This general description is, however, subject to various modifications; but as the forms of roots are of use in classification, it will be proper to describe them in the Natural History of Plants.

The roots of vegetables are generally buried in the soil from which they derive their support; but some plants are parasitic, and cannot be cultivated on the ground, as the *Viscum*, Mistletoe, often found on the branches of old Apple trees. The forests of South America abound with parasitic Orchideæ. Many species of Mosses grow on the bark of trees. Lichens on trees, palings, stones, and even on lofty exposed rocks.

The roots of some plants are not fixed to any substance, but derive their supply of nourishment from the water on which they float, as the Duckweed in fresh water, and some of the Fuci in the sea.

The substance of roots is various. In trees and shrubs it consists of wood similar to that of the trunk, its structure being fibrous. In other plants it is composed of cellular tissue, as in the Carrot and Turnip.

The *trunk*, *stem*, or *caudex ascendens*, rises immediately from the root, and constitutes the principal bulk of the plant; it is usually the frustum of a hollow cone. With regard to structure, stems are either simple without branches, as in the White Lily, and the Palms in general; or branched, as in trees and shrubs; or they are sometimes hollow, as in the grass Tribe, and many of the Umbelliferæ; but they are more generally solid.

The stems of most plants rise directly from the root, supporting the branches, leaves, and fruit; some creep along the ground, as the Ground Ivy; others are too weak to support their weight, and attach themselves to the erect stems of trees and shrubs, by twisting spirally round them, as the Convolvulus and Hop-plant.

In some plants the stem is wanting, the leaves and flower-stalk springing from the root, as the Tulip, Crocus, and others with bulbous roots.

The branches, or divisions of the stem, may be considered as merely an extension of the trunk, for the useful purpose of presenting an expansion of support to the leaves and fructification.

The most important function of the caudex, including the root and branches, is to convey to the foliage, flowers, and fruit the nourishment extracted by the fibres of the root from the soil, for which purpose its internal structure is admirably adapted.

It is an established truth, that in all organized beings a circulation of fluids is essential to vitality. By the aid of the microscope the circulation in some plants has been discovered; and it is remarkable that the appearance is very similar to that of the blood in animals. In the Chara, and in the fibres of the root of the *Hydrocharis* or Frogbit, granules of perhaps unformed cellular tissue are seen to float in a transparent fluid.

The internal structure of the stem varies considerably in different Tribes of plants; in those of the most simple organization, as the Fuci, Algæ, and Lichens, it is composed of an homogeneous mass of membranous cellular tissue enclosed in an epidermis. The cellular tissue is an



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assemblage of vesicles of from the one-thousandth to the one-thirtieth of an inch in diameter, generally colourless and semitransparent. It forms the bulk of the soft parts of plants, as the pulp, pith, and parenchyma of leaves and flowers.

In the higher and more organized Tribes it is accompanied by fibres and capillary vessels, but in Cryptogamous plants it is enveloped in membrane, and the mode of circulation is unknown.

In the stems of annual and biennial herbaceous plants, the cellular tissue is interspersed with fibre, and is in general tubular, and the tubes may be traced from the fibres of the root to the seed.

Between herbaceous plants and shrubs we perceive an intermediate link, of which the *Rubus fruticosus*, the Bramble, is an example. The substance of the stem is an approach to wood, consisting of a thin bark surrounding a cylindrical layer of cellular tissue and fibre, nearly of the consistence of wood, with a pithy centre.

The rapid developement of cellular tissue is one of the most surprising phenomena in nature. From the quick growth of some of the Fungi, which are composed of a mass of cellular tissue, each granule being not more than the three-hundredth of an inch in diameter, it has been calculated that many millions of granules have been formed and developed into cells in a minute.

The *pith* consists of cellular tissue, and with very few exceptions is without capillary vessels; when newly formed it is of a green colour, and filled with fluid; in its more advanced state it forms hollow vesicles, usually of a hexagonal form, but in some plants as they advance in age it becomes lacerated, and remains only in the state of torn fragments adhering to the sides of the interior of the stem.

The peculiar function of the pith in the vegetable economy has not yet been satisfactorily ascertained. As it occupies so important a situation as the centre of the stem, Linnæus gave it the name of *medulla*, supposing it to be analogous in its uses to the spinal cord in animals, giving life to the whole plant. That this hypothesis stands on a slight basis, will appear from the fact, that the continuity of the pith may be interrupted without any apparent check to the vital energy of the plant. Malpighi considered it to be cellular tissue, in which the sap is elaborated for the nourishment of the plant, and for the protrusion of the future buds. But it is more than probable that the pith is necessary only in the early stages of growth; for, as the age of the plant increases, and the other organs become more developed, it dries and nearly disappears, leaving the tube empty, which in the young state of the plant was filled with cellular tissue charged with sap.

The external covering of the stem, and indeed of the whole plant, with the exception of the stigma and extreme points of the fibres of the root, is called the *epidermis* or *cuticla*. This is a membrane nearly transparent, and is analogous to that so named in man and other animals. In both cases it consists of a thin substance, often possessing minute pores, and, if destroyed, is soon renewed: it is sometimes spontaneously thrown off. This delicate covering is of considerable importance to the health and preservation of the plant. In some it allows of a free evaporation of the juices; in others that inhabit dry situations, exposed to a tropical sun, it is so constructed as to retard evaporation. Hence the leaves of some succulent plants, natives of the sandy plains of Africa, retain their vitality many weeks after being detached from the plant.

As the cuticle readily allows of the evaporation of the fluids and gases generated in the vegetable, it must be porous. By the aid of the microscope, pores of a peculiar character have been observed, the edges of which have the appearance of a sphincter. These pores have been named *stomata*, and were first figured by Grew. See plate xx. fig. 3., Stomata on the cuticle of *Crassula coccinea*.

Under the epidermis is found a substance consisting of cellular tissue and fibre; it is called the *cellular integument*, and has been considered analogous to the *rete mucosum* in animals. It is composed of reticulated fibres, the forms of which vary in different Tribes of plants. The drying up and continual reproduction of cellular integument at length forms the dry, rugged covering of the stems and branches of trees, composing the mass of the bark, which is an accumulation of dead vegetable matter, extending in old trees to several inches in thickness. The extensibility of the bark in young trees is limited. At length becoming ruptured by the outward pressure of the layers of newly formed bark (one of which is produced every year, and is called the *liber*) it splits, and forms deep fissures, as may be observed in the bark of the Elm and Oak, or falls in flakes, as in the Plane tree, or peels off in narrow strips, as in the Birch and Currant.

The cellular integument in young shoots is in intimate contact with the pith; but as the tree advances in growth, the vascular system of the wood is formed between the pith and the bark. Portions of cellular tissue are pressed flat, and a continuity of this substance proceeds horizontally from the centre to the circumference of the wood; these are called *medullary rays*. This beautiful arrangement of the perpendicular vascular structure, and of the horizontal flat cellular rays, constitutes the valuable compact grain of wood, and is the cause of its great strength and durability. See plate xx. fig. 2. a longitudinal section of wood: A, the vascular structure; B, the medullary rays.

During the second year of the growth of the stem or branch, another circle is deposited outside the former, and this process of the addition of new wood continues every year until the tree dies. Between each circle of wood is found a thin layer of cellular tissue, which may easily be observed in horizontal sections of the trees of Europe; but in the hard woods of tropical regions these layers are nearly obsolete. Where they are regular and visible, they present a mode of discovering the age of a tree by the number of circles. See plate xx. fig. 1. a transverse section of the Elm: A, cuticle, B, bark, C, inner layer of bark, D, the vascular structure, E, the medullary rays.

As the tree advances in age, the interior circles of wood acquire a different colour and texture from that which they at first possessed, and become harder. This portion is called the *duramen* or heart of the tree; the light-coloured outside is called *alburnum*; it is generally known by the name of *sap*.

The addition of this colouring matter to the duramen of the wood produces that beautiful variety of figure and colour which, especially in those trees that are natives of hot Countries, makes their wood so valuable for furniture. The Ebony of the East Indies, in its first stages of growth, is white, but by the deposition of colouring matter in the duramen becomes intensely black. Rose-

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wood, and other variegated woods, the produce of the Brazils, hold the colouring matter in irregular portions in their vascular system.

Logwood, so rich in dye, has a thick coat of wood as white as that of Fir. It does not, however, appear that in all woods the variety of texture which causes them to be so esteemed for furniture is produced by the deposit of colouring matter. The beautiful mottled figure in the grain of Mahogany, Satin, and some other woods, is caused by the serpentine direction of their vascular structure, probably owing to some obstruction to their growth. Those trees which vegetate in rocky, mountainous situations, where their growth must occasionally be checked in dry seasons, always produce the finest figure; those, on the contrary, growing in a deep soil, are of a uniform plain texture.

The adaptation of the materials of the stems of plants to the necessities and comforts of Man is very extensive. In savage life the dwelling, furniture, clothing, and the implements of chase and defence, are formed of the wood and bark of trees. But the demand for these materials increases as Man becomes civilized. Without the means furnished by the stems of trees, we could have no intercourse with distant parts of the world, for of these a ship is almost entirely composed. The hull, masts, sails, and cordage are made from the stems of vegetables.

The *leaf* consists of two parts, the *petiole* or *footstalk*, and the *expansion*. The continuation of the petiole along the centre of the leaf is called the *costa* or *midrib*, its ramifications *veins*. The stalk, midrib, and veins are composed of parallel bundles of spiral vessels and sap vessels, with intervening cellular tissue. The expansion of the leaf consists of cellular tissue called *parenchyma*, covered by the cuticle, which is transparent. The parenchyma is usually green.

The part at which the upper side of the petiole joins the stem is called the *axilla*. The flowers are sometimes produced at this part; they are then said to be placed *axillary*.

The leaf is a most important organ, the investigation of the properties of which has engaged the attention of many illustrious Physiologists. From the results of a series of experiments, it has been found that leaves are the organs of respiration of the plant, and probably of digestion. Following up the analogy of the circulation in animals, the leaves have been considered the lungs of vegetables; in them the sap is exposed to the atmosphere; an evaporation of the fluids and gases not necessary to the health of the plant takes place, and an absorption of carbon and oxygen occasions the sap in the leaves to become purified, and in a fit state to be returned by the proper vessels.

That plants absorb oxygen by the leaves during the night, and give it out in the day, especially when exposed to the sun's rays, was observed first by Dr. Priestley. It has been found that the juice of a plant has become so acid by the absorption of oxygen in the night, that in the morning it would readily stain litmus-paper red, but by the evaporation of the oxygen during the day, it has again lost that property by the evening.

The absorption of carbonic acid by the leaves of plants is a remarkable feature in the vegetable economy, and most important in its results. If a plant is placed in a close receiver, containing a mixture of atmospheric air and carbonic acid gas, the latter will be wholly absorbed in a short time. The necessity for this process in the formation of wood will be readily perceived, when we consider the quantity of carbon wood contains. The absorption of carbon by vegetables is certainly one of the most interesting operations of nature, as it explains the vegetable origin of coal.

When the elaboration of the sap in the leaves is complete, it is returned by another set of vessels, and it is conveyed between the bark and the wood, where it may be discovered in the Spring of the year in the state of a viscid layer, which, when magnified, is found to contain slightly coloured granules; it is in this state called *cambrium*. It is supposed to be analogous to chyle in animals, and is gradually converted into the vessels forming the wood. If a leaf be long macerated in water, the parenchymatous parts may be separated from the vesicles; it will then be found to consist of two sets of vessels. Dr. Darwin considered them to be analogous to the veins and arteries of animals. He placed a plant of *Euphorbia heliscopia* to vegetate in a decoction of Madder root; after a few days he plainly perceived the madder passing along the midrib of the leaves, and the ramifications of the upper side, and returning by another set of vessels on the under side of the leaf to the leaf-stalk, evidently altered in colour, having undergone a change by exposure to the atmosphere, or to gases elaborated by the plant. See plate xx. fig. 4., dissected leaf of the Pear tree; A, the vessels of the upper side; B, those of the lower side.

Although the leaf is so important an organ of vegetables, some plants are destitute of leaves, but their stems are furnished with stomata, which perform the same function as the stomata of the leaves.

The *bud* (*gemma*) is a compound of the rudiments of future branches, leaves, or fruit, remaining in a latent state covered with concave scales, which protect the interior from the injuries that might be caused by the inclemency of the Winter and early Spring. There are three varieties of buds: 1. producing only leaves; 2. producing only flowers; 3. producing both leaves and flowers.

The external scales are generally covered with a coat of resinous matter or wool, for the purpose of protecting the enclosed embryo. The bud of the Horse-chestnut, previous to the expansion of the leaves, is a fine example.

There is a remarkable analogy between bulbs and buds. In the axillæ of the branches of the Orange Lily, *Lilium bulbiferum*, buds are formed which are bulbs, and by means of which the plant is readily propagated. Buds are produced, not only on the stems of plants, but sometimes on the root, of which the potato is an example.

*Glands* are elevated portions of parenchyma, filled with fluid. They are sometimes elevated on footstalks, as in the Rose and *Drosera*, Sundew; but more usually in the form of small protuberances. They are most common on the leaf and petiole, but are frequently found on the bark of young shoots, and even on the petals of the flower, causing the satiny appearance. The Ice plant, *Mesembreanthemum glaciale*, is a fine example of the glands on the leaves and stems.

The leaves and stems of many plants are furnished with a defensive armature, most probably for the purpose of resisting the attacks of animals. This is of various kinds; the *thorn* is of a different nature from other defensive appendages, being a kind of imperfect stem originating in the wood of the branch, and composed of woody fibre, which becomes extremely hard.



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*Prickles* originate in the bark; these are rigid and sharp pointed, as in the Gooseberry and Furze, and they are sometimes reflexed, as on the stem of the Rose.

The *sting* is another defensive organ, of which the common Nettle is a familiar example: some exotic species of Nettle are said to be fatal.

*Hairs* are very common appendages of plants, and are of various forms; they usually consist of a row of elongated cellular tissue, covered by an epidermis.

*Tendrils* are thread-shaped, and usually, but not always, spiral: they are generally considered to be modifications of the petiole, and sometimes of the inflorescence, as in the Vine. The tendril is the organ by which weak, climbing stems attach themselves for support to branches, or other substances with which they come in contact. The petiole of a compound leaf occasionally becomes elongated, and twists about a support, as the Pea. The Common Ivy, *Hedera helix*, produces roots from its stem and branches, which perform the office of the tendril, adhering to walls and the bark of trees, and thus climbing to their summits.

*Stipulæ* are additional appendages, and of the same nature as the leaf, at the base of which they are situated. Their peculiar function in the vegetable economy has not been discovered. Their forms are various, and are of use in classification.

*Bracteæ* are organs which, as to situation, seem placed between those of vegetation and reproduction. They generally have the form of the leaves, but are found beween the true leaves and the calyx. Nearer to the latter they are entire, although the leaves are divided; and in some cases can be scarcely distinguished from parts of the calyx.

### *Reproductive Organs.*

The *flower* is composed of the *calyx*, *corolla*, *stamens*, and *pistillum*. The latter two are essential; the former two are occasionally absent. The flower is usually placed on a stalk called the *peduncle*. This is sometimes wanting; the flower is then said to be *sessile*.

The *calyx* is generally considered to be the outward envelope of the flower; but there seems to be no certain definition of this organ. Botanists of the present day are determined to consider the flower of the Tulip a calyx; and, it would appear, almost for no other reason than because Linnæus considered it a corolla. Until some certain role for distinguishing a calyx from a corolla be discovered, why should we not call that a corolla, which by its general appearance seems to be such, although there be no calyx?

The principal use of this organ seems to be the protection of the unexposed flower; for, after the flower is full blown, in many cases it falls off spontaneously. Its anatomy is very similar to that of the leaves; it is either entire, or formed of distinct leaves called *sepals*. The calyx is of considerable use in the classification of genera.

After what has been said with regard to the calyx, a short definition only of a *corolla* will be necessary. It may be considered as the coloured envelope of the parts of fructification always within the calyx when that organ is present. The corolla usually consists of several leaves called petals: these are sometimes joined at their edges into the form of a tube; this organ is composed of cellular tissue with sap-vessels continuing from the base to the margin of the petals.



Besides the protection of the stamens and pistils, its uses are probably of considerable importance. Its remarkable sensibility to light seems to be for the purpose of facilitating by some Chemical agency the formation of the volatile essential oils, producing the grateful perfume with which these most beautiful organs are furnished. There are numerous instances which prove that the sensibility of the corolla to light is connected with the power of giving off its fragrance.

The corolla is of great use in the classification of genera.

The *nectary* is either a part of the corolla, or a distinct organ, secreting a sweet juice, which, when elaborated in the stomach of the bee, is called honey. A good example of the nectary as a part of the petal is to be found in the genus *Fritillaria*: that species called the Crown Imperial, *F. imperialis*, has an oval white-coloured space on the inner side of the petal which secretes this fluid: the small scale situated at the base of the petals, and similar to them in colour in the common Buttercup, is the nectary.

Physiologists have considered the fluid secreted by the nectary to be of use in the process of fructification; but it appears more in unison with the beautiful adaptation of useful causes and effects which we meet with in the operations of nature, that bees, butterflies, and other insects, whose entire food is this sweet juice, are furnished with collecting organs for the purpose of carrying off from the plant a secretion, which, so far from being of use, would be prejudicial if allowed to accumulate.

Within the corolla, usually surrounding the central column, we meet with what are called the *stamens*. These are generally composed of a thread-shaped stalk, thence called the *filament*, at the top of which is placed the *anther*: the filament and anther constitute a stamen; the former is not, however, essential, the anther being sometimes sessile.

The *filament* is merely a column carrying by its proper vessel the necessary fluid to the anther.

The *anther* is the essential part of the stamen: it has a membranous exterior, and consists of two or sometimes of four cells, containing minute granules called *pollen*, generally of a yellow colour and a farinaceous texture, but which, when viewed by the microscope, are seen to be of a determinate, usually oval form, or sometimes round, with spines as in the *Dahlia*. When moistened, these granules burst, and are found to scatter still smaller granules, which are considered to contain the stimulating principle of vegetable reproduction.

In double flowers the stamens are converted into petals. If a double flower be examined, it will be found that the anthers decrease in number as the petals increase, until the former entirely disappear.

The stamen is the most important of all the organs in the distribution of genera into classes and orders.

In the centre of the flower there will generally be found one or more erect columns called *pistils*; they consist of three parts: 1. the *germen*, which is the rudiment of the fruit and seed; 2. the *style*, which serves to elevate the *stigma* or summit of the pistil and to conduct the fertilizing properties of the pollen to the germen. The stigma is an essential organ. The style is sometimes absent; the stigma is then said to be sessile.

In double flowers, the pistils are sometimes converted into petals.

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The germen, or as it is now more usually called the *ovarium*, is sometimes placed beneath the calyx; it is then styled *germen inferius*, and when above the calyx *germen superius*: this distinction is of use in the characters of genere. The Apple is a good example of the germen inferius. The calyx may generally be found remaining on a ripe Apple.

The *germen* consists of one or several cells separated from each other by partitions, called *dissepiments*.

As the progress of fructification advances, the germen enlarges and becomes a *seed vessel*. This organ is exceedingly diversified in form and consistence; the immense varieties of fruits and nuts are well-known examples. This, also, is an important organ in generic description. Some plants have no seed vessel, the seed lies uncovered at the bottom of the calyx, as in the plants of the Linnæan class *Didynamia*, order *Gymnospermia*.

The *seed* in its young state, when enclosed in the germen, before it becomes a seed vessel, is called *ovulum*. In this state it is pulpy and semitransparent. A seed consists of severel parts, the most important of which is the *embryo*, or, as Linnæus calls it, the *corculum*. It in general bears but a small proportion to the mass of the seed. It has been considered to be analogous to the embryo of the chick in eggs, the mass of the seed being evidently formed for the nourishment of the embryo of the seed, as the mass of the contents of the egg is for the embryo of the future bird. In the Walnut, when divided in the centre at one end, will be found a small substance shaped like a heart, whence the Linnæan name *corculum*: this is the embryo of the future plant; the two lobes of the mass of the Walnut are the *cotyledones*, and, as vegetation proceeds, become the first leaves of the plant; from the *corculum* proceeds the stem and the root of the future Walnut tree.

Plants, in general, have two cotyledones, and are called *dicotyledones*; but some large Tribes of plants, among which are all the Grasses and the Palms, have only one cotyledon, and are called *Monocotyledones*; a few have more than two, as the *Dombeya*, Norfolk Island Pine, which has four. Conspicuous examples of the cotyledones may be observed in the incipient vegetation of the Bean and the Radish. When first coming up in the Spring, two leaves will be observed, generally of considerable thickness; they are for the purpose of furnishing nourishment to the young stem and root; when these are developed, the cotyledon leaves die away. Immediately in contact with the rudiments of the future stem and root in seeds, is a part called the *vitellus*, so named by Gærtner, who considered it analogous to the yolk of the egg.

The covering of the seed, called the *testa*, consists of several integuments, the outer of which varies very considerably in its texture, and is frequently covered with hairs, and sometimes with a complete apparatus for the purpose of wafting them to a distance, as those of the Dandelion. A very remarkable structure of this integument is found in the seeds of the Collomia, a native of North America; it consists of spiral fibres enveloped in a gum, which, when moistened, unfold and spring out: this can be observed only with a good microscope. The seed is fixed to the seed vessel by a short footstalk; at the point of the insertion of the stalk to the seed is found a scar called the *hilum*; the vital parts of the seed are attached to the inside of this scar, through which they receive their nourishment until the seed is ripened.

The *receptacle* is the base which supports the parts of fructification; it forms a considerable portion of the flowers of the class *Syngenesia*; the well-known bottom of the Artichoke is a good example. It is sometimes of a succulent consistance and elevated, and the seeds are deposited on it, as in the Strawberry.

The receptacle and its appendages are of use in characterising genera in the class *Syngenesia*.

The above is a brief sketch of the structure of Phenogamous plants in general, and may form a basis for the further consideration of the vegetable economy, but there are a great number of plants whose structure is very anomalous; thus the stems of Palms and of Ferns, and the whole anatomy of the great class *Cryptogamia*, are totally different, and require to be distinctly considered.

### *Reproduction and Growth of Plants.*

Writers of elementary Treatises of Naturel History consider the works of the Creation in three grand divisions, usually styled the Three Kingdoms; namely, Animal, Vegetable, and Mineral: between the former two an evident analogy exists, and a difficulty in defining the distinction. Animals, it is said possess vitality, are nourished by air and food, are endowed with sensation, and have the power of voluntary locomotion; but plants possess vitality, are subject to disease and death, are nourished by air and food, and occasionally possess the power of locomotion; as some of the Confervæ. We have not yet discovered that they possess sensation, yet the irritability which some plants exhibit is apparently so similar to that of some animals, whose developement of organic structure is of the lowest grede, and in which no traces of a nervous system have been discovered, that until we can distinguish between instinctive and voluntary motion, it will be impossible to determine that the locomotion of plants is not the result of sensation; therefore, in investigating the economy of vegetables, we shall proceed on safe ground, if we allow of only two grand divisions of nature, *viz.* Organic and Inorganic; and the following observations on reproduction and growth will be better understood by considering vegetables, if not identical with, at least analogous to animals. This analogy was established on so sure a basis by the experiments of Linnæus, that it has become a Botanical axiom.

The greater number of plants have the stamens or male organs and the pistils or female organs in the same flower; some have the stamens and pistils on the same plant, but in distinct flowers; there are called *Monoecious*: and others have the stamens only in the flowers of one plant, and the pistils in the flowers of another plant of the same species; these are called *Dioecious*.

If some pollen be placed under the microscope and moistened, it will be observed to burst and to scatter a fine dust with an expansive force, which is thus conveyed to the stigma. The rustic horticulturist well knows the value of a shower of rain when the Apples are in flower; it will, he says, "set the blossom;" yet it must be observed, that although a slight shower is beneficial, heavy continued rains are found to be hurtful at the flowering season, probably, by washing away the pollen. Flowers subject to these injuries, either have the property of closing their petals during rain, or they are pendent. The *Anagallis arvensis*, Poor Man's Weatherglass, is a well-known instance of the sensibility of the corolla to atmospheric influence; the petals folding up some time before the rain falls.

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In the various Tribes of plants we meet with beautiful contrivances for the preservation of the pollen, and for facilitating its access to the stigma. Many water-plants protrude their tops above the water only at the flowering season. The *Valisneria spiralis*, an Italian water-plant, has the female flowers attached to long spiral stalks, which uncoil in the flowering season and place the flowers above the water. The male flowers are produced on another plant, from which they are detached, and rising to the surface float about in abundance among the female flowers, when the flowers decay, the spiral stalk of the female flower recoils, drawing the ripening seeds down to the bottom of the water. The stamens of the Barberry are sheltered under the concave tips of the petals. When any substance, as the feet of an insect, touches the base of the filament, it contracts and the anther consequently strikes on the stigma, on which it deposits the pollen. The filaments of many other plants have the same irritability. Insects are of great use in conveying the pollen when collecting honey. It is a constant practice among gardeners to produce the numerous varieties that now adorn our green-houses and flower borders, by removing the pollen of one flower to the stigma of another differently coloured. The *Sempervivum tabulæforma*, an interesting species of Houseleek, can be cultivated only by seeds, as it does not produce offsets; but if it flowers in company with other species of the same genus in the green-house, the plants raised from the seeds will not be the same as the parent, but intermediate with it and some other species, unless all the flowers of the other species are destroyed previously to the developement of the pollen. In the class *Diœcia* are many remarkable instances of the necessity of the pollen for the reproduction by seed. The ancient Greeks, long before the discovery of the real cause, were aware that a Date tree, if alone, never produced perfect fruit. The first Weeping Willow introduced into England was a female plant; and it has ever since been cultivated by cuttings, no one having ever produced seed, consequently all the numerous plants in this Country are female. These observations will be sufficient to prove that unless the pollen have access to the stigma, the ovulum cannot become a seed.

When the seed is perfected, there are numerous methods by which it is conveyed to a proper receptacle for its future growth. It is sometimes scattered by the bursting of the seed vessel, which is effected often with considerable force. This curious property may be observed in the seed vessel of the *Balsam*: when ripe, the slightest impulse causes the valves to coil instantly into a spiral form with such violence that the seeds are scattered with noise; but the most remarkable instance is the seed vessel of the *Hura crepitans*, the Sandbox tree, which, after being kept some years, will burst asunder with a loud report. Barley and other gramineous seeds are furnished with bristles, which, from expanding by moisture, and contracting by subsequent drying, cause the seed to be removed from the spot where it first falls to a suitable nidus for its growth. Other seeds are furnished with hooks, and, thus becoming attached to animals, are conveyed to a distance, as those of the Burdock and Goose grass. The seeds of some trees are furnished with broad, thin membranes, which have acquired the name of wings; by these they are wafted to a distance. But the most complete appendage to seeds, for the purpose of dispersion, are those we meet with in the class *Syngenesia*, the seeds of which, being furnished with a beautiful stellate down, are sometimes wafted several miles before they settle upon the ground. Besides the increase of plants by seeds, which is the only true reproduction, there are other modes by which their continuance is secured; these are by bulbs and tubers of the root, buds, runners, slips, and cuttings.



A *bulb* consists of imbricated scales, as in the White Lily; (plate iii. fig. 9;) these are sometimes continuous, as in the Onion.

In the axillæ of the scales new bulbs are formed, which, as the old bulb decays, increase in size; in some plants of the *Liliaceæ* these are produced only in the parent bulb, but in the axillæ of the leaves *Lilium bulbiferum* is a remarkable example. There are some roots usually called bulbs, which must not be confounded with true bulbs; these have a solid, fleshy consistence, and are merely an underground stem, as the *Crocus gladiolus*.

The *tuberous root*, of which the Potato is a familiar example, consists, in the interior, of a mass of compact cellular tissue; the exterior is remarkable in its properties of producing buds. If a part of the root possessed of a bud is cut off, a plant may be raised from the cutting; this is the usual way of cultivating Potatoes. The roots likewise throw off fibres, on the sides of which fresh tubers are protruded; thus a Potato root will be found to consist of several Potatoes connected with each other by a thick fibre. Of the several kinds of *buds*, the *leaf bud* only is concerned in the continuance of the plant. It may be removed from an aged to a young plant, in the bark of which, if it be inserted, it will produce a branch; this process gardeners call budding. The buds which originate in the Summer continue inactive during the Winter, and do not expand till the Spring. They are usually placed in the axillæ of the leaves and the extremity of the branches, but are occasionally found on other parts of the plant, sometimes on the root. Buds originate in the outward layer of the vascular structure, and form the young shoot, which each year perfects a new layer of wood like the parent stem from which it sprang. As the growth of the tree advances and fresh layers of wood are added, the point from which some of the earliest shoots proceeded will be deeply imbedded in the trunk, and the wood of the branch will be found to originate at this point proceeding outwards; this is the cause of the knots we find in Fir and other woods. There is a striking coincidence of vegetable buds with those observed on some of the lower order of animals, though on the latter they are more immediately concerned in reproduction. The *Hydra* or *Polype* produces buds, which in a few days spread out their arms, similar to the parent, and when dropping off become a perfect animal. The increase of plants by means of runners or stems trailing on the surface of the ground seems to be nearly allied to that by buds, as the bud which the stem produces has the property of throwing out roots. Gardeners increase their stock of Strawberries by means of the young plants formed on the creeping shoots.

*Suckers* are shoots produced from the crown of the root in some plants, most abundantly in those whose principal stem, which they surround, perishes after perfecting the flower and fruit, as the Plantain, Banana, Agave, &c.

Many plants have the property of producing roots from every part; and the extension of a plant by cuttings or slips is an artificial method of anticipating the

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increase well known to gardeners. If a leaf of *Bryophyllum calycinum* be cut into several pieces, and the parts be planted in separate pots of earth, they will throw out roots, and a plentiful supply of young plants will be obtained. Here again we may refer to the analogy of the Hydra, which may be divided into parts which will soon become perfect animals, and will produce buds and offsets.

The growth of plants is a subject at present but imperfectly understood: of the nature of the formation of cellular tissue no certain discovery has yet been made. From some experiments on the increase of vegetables, in which water and atmospheric air could be the only agents from which the accumulation of vegetable matter were derived, it is probable that the Chemical combinations of oxygen, hydrogen, nitrogen, and carbonic acid, together with the action of light, are the causes of its formation; but in what manner these fluids are converted into the solid substance of the tissue of plants remains a mystery. That water and air alone are sufficient for the formation of vegetable matter is obvious, by observing Hyacinths and Narcissuses growing and flowering in water-glasses: if a quantity of sand be carefully washed, so as to deprive it of every particle of animal and vegetable matter, and some seeds that readily vegetate, as Peas or Beans, be sown in it and watered with distilled water only, they will become plants in which cellular tissue will be rapidly developed. In *La Physique des Arbres* of Du Hamel, published in 1758, are some interesting experiments on the growth of trees. A Willow planted in a known quantity of earth increased one hundred and nineteen pounds in weight in five years, the earth having in the same period lost only two ounces in weight.

The presence of atmospheric air is essential to the growth of plants; seeds will not vegetate if they are sown in a pot of earth, then watered and placed under the exhausted receiver of an air-pump, or if they are buried too deeply in the ground; but in the latter case they will retain their vital principle for an indefinite period: earth taken from a great depth will soon be covered with plants, the seeds from which they are produced having lain dormant since they were first formed. This latent vitality of seeds seems to be of a similar nature to that possessed by some of the fresh-water animalculæ, which may be kept dry for a year, and probably much longer, and become reanimated when moistened.

For the vegetation of the seed when placed in the ground, water and air alone, together with a sufficient degree of temperature, are sufficient; the integuments of the seed burst, the young root proceeds downwards, and the rudiments of the stem and first leaves, called the *plumule*, rise perpendicularly; the root becomes elongated by addition, chiefly at its extremity; the cotyledons or seed leaves, which are the expanded lobes of the seed, decay as the plumule advances.

As the plumule expands, the action of light begins to operate, and is essential in every future stage of the plant. Without light, the leaves are imperfectly developed, and remain of a pale yellow colour. The green colour is undoubtedly the effect of some Chemical combinations, or decompositions caused by the action of light, which certainly occasions the liberation of oxygen by the leaves. When leaves decay and are unable to perform this function, they become of the same pale yellow colour which they are of when the plant is allowed to vegetate in the dark.

Heat is essentially requisite for the growth of plants: without a certain degree of warmth no vegetation can proceed; the degree required depends on the organization of the plant. Seeds and bulbs, in their dormant state, are not affected by changes of climate; but immediately vegetation proceeds, or rather to effect it in the first instance, the temperature of the climate in which the seeds or bulbs have been produced is required to be raised by artificial means, if removed to a colder climate, before we can succeed in their cultivation. It yet remains doubtful whether the plants of tropical climates can to any degree be naturalized in colder regions. We certainly cultivate plants brought from lower latitudes than our own, as the *Aucuba Japonica*, but it should be ascertained in what degree of elevation these flourish in places in which they are indigenous. The Cucumber, native of the Northern parts of India, has been cultivated in England two hundred and sixty years; but it yet requires the same degree of artificial heat that it most probably required when first introduced. It has been supposed that plants would, to a certain extent, become naturalized in colder climates; but if this were the case, would they not since their first creation, without the aid of Man, have disseminated themselves to distances from the spots on which we now find them, and on which the earliest discoverers first found them?

When then the incipient vegetable is furnished with a supply of moisture, air, light, and sufficient temperature, the formation of the perfect plant proceeds, its organization becomes daily more developed, the rudiments of which, to a very great extent, existed in the seed.

As soon as the young root is developed, it commences its important function of absorbing the surrounding moisture, which is conveyed by its proper vessels to the stem and leaves. The circulating fluid necessary for the nourishment of the plant has acquired the name of *sap*. To discover the cause of the motion of the sap, numerous experiments have been made, and almost as many theories have been proposed. That there is a rapid absorption by the root and the fluids transmitted to the most remote parts of a plant is abundantly proved by the fact, that in a hot, dry day, if a plant be allowed to droop in consequence of the great evaporation of the fluids by the leaves, if water is applied to the root, in an hour or less every part of the plant expands.

When the leaves of the plumule are expanded, they become the receptacles for the rising sap, which in them is prepared by the effects of exposure to the influence of the atmosphere and light, for its future function of forming fibre and tissue; for this purpose it is returned through the petiole to the stem, and becomes deposited, and forms the first layer of wood. A portion of the sap also is necessary for the first layer of the bark. As the shoot advances, fresh leaves are formed on the upper part; the lower leaves continue to elaborate the sap, by which, as it returns and is deposited, the lower part of the stem becomes enlarged, buds begin to form in the axillæ of the lower leaves, and gradually on those further up the stem, and this process continues till Winter, during which season the fibres become more rigid and condensed. It will be found, on examining the young shoot, that the fibres have been arranged to form tubes, being the first formed sap-vessels that surround the pith.

On the arrival of Spring, the terminal bud and those formed in the axillæ of the leaves during the preceding Summer expand, and a similar process goes on;

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but in the stem already formed a fresh deposit of woody fibre, interspersed with sap-vessels, takes place; and it will be found that, the wood first deposited in the Spring is of a less compact form, and that the sap-vessels are more numerous, than in that formed during the Summer and Autumn. As the season advances the wood becomes harder; thus are produced those circles of compact woody fibre which, in a horizontal section of the tree, by their number indicate its age.

The glutinous substance called *cambium*, which in the Spring is found between the inner bark and the wood, and which is supposed to be secreted by one or both, probably deposits the cellular tissue which forms the medullary rays proceeding from the centre of the tree through the vascular structure to the bark, and through which a communication of the juices of the plant takes place.

Although no vessels have been discovered in the medullary rays, it is certain that a circulation of the proper juices of the plant is carried on in them. If we examine this part with a microscope in those trees which contain much colouring matter, we find that it is in this part that the colouring matter is chiefly deposited.

Various opinions have been formed of the cause of the ascent of the sap through the vessels of the wood to the leaves, and its descent to the inner bark to be converted into new wood and bark. Some of the earlier Botanists supposed it to be the result of capillary attraction; those of a later date, among whom is Du Petit Thouars, consider that the evaporation of the fluids from the leaves causes more sap to rise to supply the deficiency, the operation continuing to the ultimate fibres of the root; but this will not account for the fact, that if the stems of most plants be cut across, the sap will flow abundantly from the vessels: in this case the supposed necessary evaporation from the leaves for the flow of the sap is dispensed with. This flowing of the sap from the cut stem will last for a considerable time, and with a force and rapidity that renders it difficult to assign any probable mechanical cause. Hales fixed a mercurial gauge to the stem of a vine, which he then cut off two feet and a half above the ground; the mercury rose in the gauge by the pressure of the flowing sap to the height of thirty-eight inches, equivalent to a column of water of forty-three feet, being a power more than equal to the pressure of the atmosphere.

This rapid and forcible ascent of the sap cannot be accounted for by the opinion of Malpighi, that it is caused by the contraction and dilatation of air contained in air-vessels.

Du Hamel supposed heat to be the chief agent;-Saussure that the sap-vessels possess a peculiar irritability, and are capable of contracting by the stimulus of the fluid first rising into the tubes by capillary attraction; but he has not explained how the first portion of the tube afterwards expands to receive a fresh supply. Mr. Knight is of opinion that the circulation is carried on by means of the alternate contraction and expansion of the medullary rays.

Of these hypotheses, the most ingenious are so unsatisfactory, and so inadequate to explain the causes of the ascent and circulation of the sap, that it may be as well to consider whether the motion of the fluids in plants is not caused by the vital principle they may possess. It has been observed, that the blood of an animal retains its vitality some minutes after it has left the vein. It is probable that the more we consider vegetables identified, to a modified extent, with animals, the greater chance we have of acquiring a true knowledge of their Physiology. That this identity is not so hypothetical as may at first appear is evident from the important experiments of M. Marcet, who found that those poisons were fatal to plants that act only on the nervous systems of animals; and it is a remarkable fact, that the electric fluid is equally destructive of animal and vegetable life, without causing any derangement of the organic structure of either.



All who have witnessed the circulation of the sap in Chara must allow that there is no obvious mechanical cause for it. The opinion of Amici, that it is effected by Galvanic influence, must have been formed with but slight consideration. We do not find that the motion is accelerated or retarded when the Chara is insulated in a glass vessel, or surrounded by the powerfully conducting metals of which the microscope is made, and these in immediate contact with the water containing the Chara. Without allowing a vital energy to the sap, it does not seem probable that any cause for its circulation will be discovered. The vascular structure, even in the same plant, varies considerably; some vessels are continuous, others are divided in their length by membranous diaphragms; these membranes may possibly be of use in the elaboration of the juices of the plant. The discovery of the remarkable passage of gases by Humboldt and Gay Lussac, and of fluids of different densities by Dutrochet, through moistened animal membrane, may perhaps lead to some discovery of the nature and functions of these membranous divisions.

Of the different vessels observed in plants, the most interesting, both on account of their wonderful mechanism and the obscurity that exists with regard to their uses, are what are called the *Spiral vessels;* these are found most plentifully in herbaceous plants, surrounding the pith, and extending into the leaves, petals, and even the filaments: they also abound in the scales of bulbous roots. If one of the outer scales of a bulb be gently torn asunder in a horizontal direction, the two parts will be found to adhere by almost invisible threads; if these are examined by a microscope, they will be found to consist of the thread lengthened out, but still retaining its spiral form; or if the stems and leaves of herbaceous plants are boiled or macerated in water, the spiral vessels may easily be separated for examination: they vary in diameter, being usually from about the 2000th to the 500th of an inch. The spire generally, especially in *Dicotyledonous* plants, consists of a simple convolution; but in *Monocotyledons* they are frequently composed of two or more. The extreme fineness of the thread has not allowed of any certain discovery of its true form; but the most probable opinion is, that it consists of flat membrane: the spiral vessels are enclosed in a thin transparent tube, and are usually in bundles of several together.

Besides the spiral vessels, others are found which resemble them, but the thread appears as if broken into small pieces, as at plate xx. fig. 5: these have generally a conical termination, and are joined to another as at *a*. In some macerated stems of *Nasturtium officinale*, or Water Cress, all these vessels were jointed in this manner, but no interruption of the real spiral vessel was observed; they appeared to be continuous throughout their whole length.

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There are other vessels that are termed *ducts*; the joints of these are usually short and terminated with membranous extremities; the sides appear in dots: these and the last described are probably modifications of the spiral vessels.

The preceding sketch must be considered only an outline of the anatomy, growth, and reproduction of the greater portion of *Phænogamous* plants, or those with determinate sexual organs; but there are several modifications that require to be separately noticed.

The usual mode of the increase of the stems of plants is by annual external layers of wood; this has been called the *Exogenous* structure, and is confined to *Dicotyledonous* plants. The stems of *Monocotyledonous* plants are not increased by external layers, but by a continued addition of fibre, cells, and vessels, in or near the centre; this is called the *Endogenous* structure, of which the Palms are examples. Those stems that are increased by external addition are hard in the centre and soft on the outside; those, on the contrary, which increase by additions to the centre, have the exterior of the stem, when they have arrived at a considerable age, sometimes so hard as to turn the edge of a tool. Plants of this structure possess no medullary rays, but the whole formation is longitudinal; and, although the stem is sometimes many feet in diameter, it does not consist of wood. The structure of the stems of plants in the natural order *Gramineæ*, or Grass Tribe, is a modification of the Endogenous mode of growth: these are hollow with solid partitions. The Bamboo is a remarkable instance: the stem of this noble grass is sometimes nearly a foot in diameter, and the liquid caoutchouc is sometimes imported in casks formed of its joints. Plants of this structure have no true bark. The exterior of the stems of the Palms consists of the decayed bases of the footstalks of the fronds, all of which before they decay are terminal, and the stem is not branched. See the figures of the Cocoa-nut tree and Fan Palm in pl. xix. In the same Plate is a figure of *Zamia elliptica*; the reticulated appearance of the dwarf stem is caused by the decayed bases of the fronds. The genus Calamus, which produces the ratan and other canes, is nearly allied to the Grasses through the Bamboo.

The physiology of the various Tribes of *Cryptogamous* plants having no determinate sexual organs differs materially from those in which these organs are developed, and from each other. Of these the most important are the *Filices* or Ferns, which form a prominent feature in the vegetable creation, especially in tropical climates, assuming there an arborescent character, the stems sometimes attaining the height of fifty feet.

The stem of a Fern resembles that of a Palm, in being formed by the adhesion of the bases of the fronds, but differs from it in having the centre composed of cellular tissue; very few Ferns are furnished with true stems.

The stalk of the frond is composed of hard, compact, woody fibre, interspersed with cellular tissue. In the early stage of its growth, in most of the genera, the apex is rolled inwards like a scroll, which unfolds as the plant expands. The reproductive organs of Ferns are situated on the veins of the under side or margin of the leaf; they consist of semitransparent capsules called *thecæ*; these are usually congregated in heaps called *sori*. Each of the thecæ is surrounded by a ring, which, on the side of the capsule next to the surface of the leaf, is connected by a short footstalk to a vein. The thecæ are sometimes formed beneath the cuticle of the leaf, by a portion of which they are covered, when matured they are called *indusia*. The sori are sometimes in round heaps, as in *Polypodium vulgare*, pl. xiii. fig. 8, arranged in two lines on the under side of the leaf. In *Hymenophyllum*, fig. 11, the sorus is contained in a cylindrical receptacle, inserted into the margin of the leaf. When the thecæ have arrived at maturity, the ring by which they are surrounded breaks, and the capsules burst open, and allow very minute grains called *sporules* to escape; from these, which are analogous to seeds in Phænogamous plants, reproduction is carried on. Fig. 7 is a magnified sorus, composed of an aggregation of thecæ; at *c* is seen one detached, with the ring and pedicle by which it is attached to the leaf; *d*, the ring breaking and the sporules escaping; *l*, a highly magnified sporule. It was not until the year 1789 that these minute granules were discovered to be the seeds of the Fern; they had not even been noticed before the acute eye of Swammerdam detected them in 1670. Before this time there was an opinion that Ferns were reproduced from invisible seeds:

"We have the receipt of Fern seed, we walk invisible."

These sporules have the remarkable property of retaining their vitality for a very long period; they have been shaken out from dried Ferns that have been kept in a Herbarium more than a hundred years and have vegetated. The term sporule has been adopted by Botanists to distinguish them from seeds, from which, although analogous, they are suspected to differ materially in organization.

At pl. xiii. fig. 12, is a portion of the leaf of *Polypodium filix mas*, with the indusia arranged in lines: fig. 13 an indusium magnified, partly covering the thecæ. There is a considerable variation in the form of the frond and arrangement of the fructification in Ferns. In *Scolopendrium vulgare*, the common Hart's Tongue, the frond consists of a long, lanceolate leaf with linear sori on the under side. In *Blechnum boreale* the fronds are pinnate, and of those which spring from the same root some are barren, others fertile. In the genus *Osmunda*, one of the fronds is metamorphosed entirely into capsules; the frond of *Pteris aquilina*, the common Brake, is compoundly pinnate.

The genus *Equisetum* consists of plants with branched stems, but without leaves, the stems are striated and hollow, and are remarkable for containing a considerable portion of silex under the cuticle. *E. hyemale*, on account of this property, has been imported from Holland to polish cabinet-work, ivory, &c.: it is known by the name of Dutch Rushes.

The fructification of Equisetum is terminal, and consists of a receptacle, having the appearance of a catkin covered with peltate scales, with membranes on the margin; under these membranes are the thecæ: to each of the sporules are attached four elastic filaments, the ends of which are club-shaped. Some Botanists are of opinion that these are the anthers, and the apex of the sporule the stigma; which is not very probable, if we consider that the sporule is not the seed-vessel, but the actual embryo of the future plant. It is possible, however, that Equisetum is the connecting link between Phænogamous and Cryptogamous plants, as supposed by M. Brongniart; the Equiseta have certainly, in the mode of fructification, an appearance of affinity with the genus *Cycas*.

Pl. xiii. fig. 1, *Equisetum arvense*: *a*, barren stem; *b*,



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fertile stem; *c, d*, sporules, with the elastic filaments; *e*, peltate scale, with the membranes covering the thecæ.

The genus *Lycopodium*, Club-moss, consists of plants with creeping stems, covered with small, closely imbricated leaves, in the axillæ of which are the thecæ, containing very minute sporules.

Pl. xiii. fig. 4, *Lycopodium clavatum: a b*, thecæ. Nearly allied to Lycopodium is the genus *Isoetes*, a submersed water-plant, found in lakes; the thecæ, as in Lycopodium, are axillary. Fig. 2, *Isoetes lacustris: a b*, the thecæ.

*Pilularia*, and several genera allied to it, have capsules containing two sorts of granules, one of which has been considered to be anthers, or bodies analogous, but it is probable they are only abortive sporules. Pl. xiii. fig. 3, *Pilularia globifera: a*, the four-celled capsule, containing the two sorts of granules.

As we descend in the series, and investigate the physiology of plants further removed from the Phænogamous structure, the anatomy and reproductive functions become more anomalous and obscure. The *Musci*, or Mosses, although possessing considerable organization, and even an analogy in their forms to more perfect plants, possess neither vessels nor woody fibre, but consist, both stem and leaf, of cellular tissue only.

The roots of Mosses are filiform; from these arise the stem, often branched, and sometimes pectinated; the leaves are most commonly densely imbricated round the stem; they consist of an expanded lamina of tissue, with a midrib and costæ; they are often serrated. The reproductive organs are of two kinds. On the top of the branches of many species is found an expanded kind of receptacle of a stellate form, in which are small oblong or club-shaped bodies; the same are found sometimes in the axillæ of the leaf. Hedwig considered these to be anthers; an opinion which has been very generally adopted. But it has been observed that these supposed anthers fall off and produce new plants, and it is therefore very probable that they are analogous to buds, and are produced by a superabundance of the juices of the plant; and this is more likely, when we consider that only some species, and these in different genera of the Mosses, are furnished with these supposed anthers, and that sometimes an elliptical congeries of apparent buds are found instead of the usual capsule, as is the case with *Phascum alternifolium, Eng. Bot.* 2107. There cannot be much doubt that the only true organ of fructification of a Moss is the urn-shaped capsule or theca, with which each species is furnished; this is usually elevated on a footstalk, though sometimes sessile, or nearly so. The footstalk is usually swelled at the base, and is surrounded by a circle of leaves differently formed, called the *perichætium*. This name is also given to the circle of leaves surrounding what has been supposed to be the male flower. If the theca is examined in the early stage of developement, it will be found to be the central one of several small ovate bodies, enclosed in a membranous covering, which, as the theca expands, bursts, and, as the footstalk lengthens, is carried up on the summit of the theca: this remaining part of the membrane is called the *calyptra*, or veil; this usually splits on one side, and finally falls off. The theca will now be found to have a lid with a conical apex, which afterwards lengthens into a sort of beak, inclined to one side; this, which is called the *operculum*, falls off also at maturity, discovering the open theca, in the centre of which is an axis, called the *columella*; the space between this axis and the sides of the theca contains the sporules or embryos of the future Moss. The upper part of the theca, to which the operculum was attached, is called the *annulus*, within which is a membrane, being a continuation of the inner coat of the theca; this membrane is usually split into divisions, called the teeth, which are always in number a multiple of four, as eight, sixteen, thirty-two, or sixty-four. The termination of the outer coat of the theca is sometimes split into teeth; this circle of teeth forms what is called the *peristomium*. In *Gymnostomum* and several other genera the teeth are wanting. The calyptra of *Polytrichum* is sometimes double, the theca quadrangular, and the columella winged; in *Tortula*, the teeth are twisted spirally.



Pl. xiv. fig. 1, *Shagnum latifolium: a*, the toothless theca magnified. This is one of the Mosses that constitute the principal part of the spongy vegetation of a bog. The vegetating part being on the surface, the lower decaying part of the plant becomes compressed and matted together, and forms the peat which, in Ireland, and in many parts of England, furnishes the entire fuel required. In some bogs the lowest part has been found to be nearly as compact and black as coal, and it is probable that the coal formation is of similar origin. Fig. 2, *Phascum curvisetum*, of the natural size: *a*, a single plant magnified; *b*, the capsule with the short footstalk and detached calyptra. Fig. 3, *Gymnostomum ovatum: a*, the toothless theca; *b*, the theca, the summit covered with the splitting veil; *c*, a plant in its young state. Fig. 5, *Splachnum mnioides: a*, the theca, the peristomium having sixteen teeth.

The genus *Andræa*, of which four species are figured in *Eng. Bot.*, is remarkable in having a dehiscent theca, splitting into four valves, the points of which adhere to the operculum. This genus seems the connecting link between the Mosses and *Jungermannia*; being allied to the former in possessing an operculum, and to the latter in the dehiscent theca.

The *Hepaticæ*, (Liverworts,) though allied to the Mosses, differ from them in having no operculum to the thecæ, which are dehiscent; there seems to be no general description by which this Tribe can be identified, and a short definition of each genus is necessary.

*Jungermannia* is a genus numerous in species, sixty-six being figured in *Eng. Bot.* Of the stems some are erect, and others creep on the ground; they are frequently branched, and are furnished with very curious and variously formed leaves or fronds; at the summit of the stem is a sheath or perichætium, usually toothed, from which arises a stalk of a fleshy texture, generally white, supporting the theca, which at maturity bursts into four valves. The sporules are attached to numerous spiral fibres. These are either single or double, twisted about each other, and are contained in thin, elastic tubes. The Jungermanniæ, as well as the Mosses, are furnished with organs, which Hedwig and other Botanists have considered to be anthers; they consist of round, reticulated bodies on short footstalks. On the points of the leaves of some species, as *J. incisa* and *ventricosa, Eng. Bot.* 2528 and 2568, are granulations, which Dr. Smith describes as buds, and says, "In consequence of this ample mode of increase, it seems, the capsules are rarely perfected." What the peculiar functions of these gemmules are has not been ascertained with any certainty; they seem to be analogous to the supposed male flowers of the Mosses, and are probably of the same nature. The theca, in its

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young state, is enveloped in a membranous case, of the same nature as the calyptra of a Moss; as the theca advances, it bursts the bag, but no part of it is carried up on the theca, as is the case with Mosses. Pl. xiv. fig. 13, a plant of Jungermannia: *a*, the same magnified, the ripe theca opening; *b*, the same in the early stage; *c*, the expanded theca, with the spiral threads and sporules; *d*, the latter considerably magnified.

The reproductive organs of *Marchantia* are of three kinds, springing from the surface of a frond which spreads on the ground and is attached on the under side by roots. On the top of some of the stems arising from the frond are peltate lobed receptacles, on the under side of which are thecæ containing sporules; other stems bear receptacles with oblong bodies inserted into the disc, and there are also sessile cups on the fronds, in which are small, green, lenticular granules, evidently analogous to buds. The true sorts of receptacles seem to bear some analogy to the flowering of Monoecious plants, but the nature of the organic functions, in these lower Tribes of vegetables, is but little understood. The seeds are, as in Jungermannia, connected by very elastic hairs. Pl. xiv. fig. 15, *Marchantia polymorpha*, a very common species, found in shady, moist court-yards, and often troublesome in green-house garden-pots: *a*, the receptacle, furnished with thecæ; *b*, a receptacle, furnished with the oblong bodies on the disc; *c*, one of the cups containing the buds.

The thecæ of *Anthoceros*, *Eng. Bot.* 1537. are on a stem, springing from a perichætium, situated on the surface of the frond. When young, they are furnished with a calyptra, which bursts when matured into two valves on the top of the footstalk. The sporules are fixed to elastic fibres.

The receptacles of *Sphærocarpus*, *Eng. Bot.* 299. are pear-shaped, pellucid, and arranged in tufts on the surface of the frond; they contain a small globular theca, within which are the sporules. There are other genera allied to these.

The genus *Chara*, which has become so interesting on account of the circulation discovered in several of its species, has till lately been generally considered a Phænogamous plant, and as such was left by Linnæus in *Monoecia Monandria*, though he at first held it to be Cryptogamic, which is now the prevailing opinion. All the species, including *C. translucens*, (now elevated to a genus called *Nitella*,) are submersed water-plants. The stems are slender and branched; the branches often in whorls, with a whorl of fibres at their base. The fructification is axillary and sessile, and consists of two differently constructed organs. That which has been considered the anther is a small round substance of a red colour; the surface is composed of triangular scales, which separate at maturity; it is filled with a mass of undulate filaments. The scales are composed of radiating hollow tubes, containing minute coloured granules. What has been considered the pistillum consists of an oval, sessile capsule, striated spirally, with a membranous covering; the summit indistinctly five-cleft, and filled with minute sporules. M. Brongniart considers this capsule Monospermous; the capsule being, in his opinion, indehiscent, and the white granules which it contains not sporules, but of the nature of albumen; but as the Chara is now much cultivated for observation, it is to be hoped that some discoveries will be made of the true nature of its reproduction, which will throw some light on the obscure physiology of the plants allied to it. All the species of Chara have a considerable incrustation of carbonate of lime on the outside of all the branches and filaments. Nitella is free from this, and the circulation can be more readily observed in it. Plants of the Chara require the exterior coating of earthy matter to be removed before the circulation can be seen. The Nitella and Chara are easily cultivated in a glass globe filled with water; if frequently changed, and exposed to the light, they will freely seed, and reproduction may be carried on.



Descending still lower in the series, we arrive at those plants that are destitute of a central axis, and that possess no leaves; and here we certainly have lost all traces of a sexual organization, and a great difficulty arises in finding distinguishing characters of structure. The limits of the three great Orders, Lichenes, Fungi, and Algæ, are not well defined; and so little is known of their reproductive functions, that Fries and others, who have studied these Tribes with great attention, are of opinion that a sporule of any one of the three may produce a Lichen, a Fungus, or an Alga, according to the medium in which it may happen to be placed at the time its vegetating powers are called into action, and will produce a Lichen if in a dry situation, a Fungus if in a moist, or an Alga if in water.

*Lichens* consist of a frond, usually termed a *thallus*, spreading on the surface of the earth, stones, trunks of trees, palings, and particularly on lofty exposed rocks: it is composed of two layers of tissue; the outer of these is cellular, and the inner cellular and filamentous; from the latter arise discs in the form of shells, called *apothecia*, which push through the outer layer: they contain membranous tubes; these are analogous to thecæ, and contain the sporules. The separated cellules of the tissue of the inner layer of the thallus are believed to be capable of reproduction.

There are considerable variations in the forms of the thallus and situations of the apothecia; and from these the generic characters are formed, which are, however, subject to some uncertainty. Some species of *Nostoc*, a genus in the Order Algæ, have been discovered to be the same plants that had been arranged in the Order Lichenes, the former growing in damp places, the latter in dry.

Pl. xvi. contains some of the various forms of Lichens. Fig. 1, *Spiloma tumidulum*. Fig 2, *Solorina saccata*. Fig. 3, *Lecidea geographica*, a beautiful species, bearing some resemblance to a coloured map: it grows on exposed rocks. Fig. 4, *Lecidea canescens*, which may frequently be observed in white or grey patches on wood or palings exposed to the weather. Fig. 5, *Calicium sphærocephalum*, with the apothecia raised on footstalks composed of a continuation of the thallus. Fig. 6, *Gyrophora Arctica*, the celebrated Tripe de Roche, which probably saved the lives of Captain Franklin and his companions in their Arctic journey. Fig. 7, *Variolaria amara*. Fig. 8, *Lecanora tartarea*, known in Commerce by the name of Cudbear; it produces a purple dye, and is imported largely from Norway. Fig. 9, *Lecanora candelaria*, so named from being used to dye of a yellow colour the candles used in religious ceremonies in Sweden. Fig. 10, *Parmelia globulifera*. Fig. 11, *Parmelia stellaris*. Fig. 12, *Cetraria Islandica*, Iceland Moss, which contains a mucilage considered to possess restorative properties: in Iceland it is an article of food, being boiled in milk, or dried and made into bread. Fig. 13, *Sticta pulmonacea*. Fig. 14, *Peltidea canina*. Fig. 15, *Rocella tinctoria*, an important dye called Orchal, and is imported chiefly



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from the Canary Islands. Fig. 16, *Cenomyce rangiferina*, the Rein-deer Lichen, being in Lapland the chief support of that valuable animal; it clothes the entire surface of the ground in the large pine forests of that Country. It not unfrequently grows on exposed heaths in England. Fig. 17, *Cenomyce bellidiflora*, with beautiful scarlet apothecia on footstalks. Fig. 18, *Beomyces roseus*. Fig. 19, *Coralloides sphærophoron*. Fig. 20. *Ramulina fastigiata*. Fig. 21, *Usnea florida*. Fig. 22, *Usnea barbata*. Fig. 23, *Collema palmatum*. Fig. 24. *Graphis dentritica*.

In the *Fungi* or Mushroom Tribe, the anatomy of the whole plant, and particularly the reproductive organs, are so different from what we observe in the more perfect plants, that they seem almost to have lost the character of vegetables, of which they scarcely possess either the form or colour. We had some analogy to leaves in the frond of the Lichen; this is now lost; we have here no organ that can be considered of the nature of the apothecia, the substance consists of cellular tissue occasionally arranged in filaments. The sporules are usually disposed in a series in elongate tubular cells in some part of the exterior surface of the plant; these are called *Sporidea*. Sometimes the whole inside of the plant is filled with sporules mixed with a few filaments, of which the puff-ball is an example. It is supposed that every part of a Fungus produces sporules, which are probably merely the separated cells of tissue. If, as is considered to be the fact, the whole of the powdery mass of the interior of the *Bovista gigantea* consists of inspissated cellules which are the real sporules, we have a developement of reproductive power which is certainly of a most wonderful nature. From some ingenious and accurate calculations that have been made on the rapid growth of this plant, it has been computed that more than 60,000,000 cells of tissue have been produced in one minute; and, although we cannot at present discover the necessity in the economy of nature for this amazing reproductive power, yet it bears a striking analogy to the almost miraculous reproduction of the lower tribes of animals. Of the animalcules produced in vegetable infusions, it has been observed that a square inch of the water containing the decaying vegetable matter, and in which three days before not a single animalcule could be found, there were 1000,000,000 individuals of the genus *Monas*.

Although the internal organization of the Fungi is so simple, the external structure presents considerable variation of form, in the different genera of which the Order is composed. In the genus *Agaricus*, of which the Mushroom is an example, the plants, when at maturity, are found to consist of a stem, (*stipes*,) supporting the head, usually of a convex or conical form; sometimes concave and even funnel-shaped, called the *pileus*, which is furnished on the under side with thin membranes radiating from the centre called gills; (*lamellæ*;) they are either single or in pairs; some extend from the centre to the circumference, others only a part of the distance; sometimes they are decurrent on the stipes, and sometimes free: these variations are of use in distinguishing the species. That part of the gill which contains the sporidia is called the *hymenium*; in the embryo state of the plant the whole is enclosed in a membranaceous envelope called the wrapper; (*volva*;) as the plant expands this is ruptured, and remains surrounding the base of the stipes; before the edge of the pileus is expanded it is attached to the upper part of the stipes by a membrane called the veil; (*velum*;) part remains hanging loose round the upper part of the stipes, and is called the *annulus*, and part remains sometimes adhering to the edge of the pileus in fragments, and is called the *cotina*. This description refers to those Fungi placed by Linnæus in the genus *Agaricus*, which has been divided into several genera by later Botanists. The species of the genus as at present established have no volva; those with a volva are arranged in the genus *Amanita*. Pl. xvii. fig. 1, *Amanita muscaria*, Persoon. Fig. 2, *Agaricus mollis*.

Plants of the genus *Boletus* differ from the *Agaricus* chiefly in being furnished with pores on the under side of the pileus, which is of a hemispherical form; the substance is more tough and elastic than that of an *Agaricus*; it most commonly is fixed by the side to the substance on which it grows, as the stems and branches of trees. Sometimes the pileus is supported on a stipes; indeed there is no other certain distinction between an *Agaricus* and a *Boletus*, but the lamellæ in the former and pores in the latter, as an *Agaricus* is sometimes fixed by its side to the substance on which it vegetates: these two genera are the most conspicuous of the Order.

The species of the genus *Hydnum* in their general form resemble the *Agaricus*, but differ from both these and *Boletus* in the fructification, which is the reverse of *Boletus*; the hymenium is covered with spiny, awl-shaped processes which contain the sporules.

The genus *Phallus* consists of those Fungi that have a reticulated pileus which is smooth on the under side; in the interstices of the reticulations are cells containing the sporules, which are immersed in a layer of mucus.

The species of the genus *Clathrus* have a reticulated, latticed, hollow form, the ramifications connected on every side; the sporules are enclosed in the substance of the branches; when young, the plant is enclosed in a membranous volva.

In *Helvella* the pileus is membranous, inflated, of no determinate form; the margin is deflexed.

The species of the genus *Peziza* are cup-shaped and sessile; they bear a considerable resemblance to the hollow disks of some of the Lichens, from which they seem only to differ in having no thallus; the sporules are contained in the substance of the cup, which is sometimes beautifully coloured.

*Clavaria* consist of plants usually of a club-shaped form, sometimes branched like coral; the sporules are imbedded in the upper part.

The *Lycoperdons* are in general globular, pear-shaped; they almost entirely consist of a mass of sporules mixed with a few filaments, and enclosed in a case the substance of which has the appearance of leather; these cases generally burst on the upper side, and the sporules are emitted; they are so small and light that they appear like a brown-coloured smoke issuing from the apex of the plant.

The genus *Mucor* contains all those plants that constitute mouldiness; they in general consist of very slender stems, the head of which is globular, and contains the sporules; they are certainly at almost the lowest grade of organization; the stem seems to be formed of a single line of cells of tissue slightly connected with each other.

The foregoing is a short description of the Order as established by Linnæus. Since his time the whole Tribe has been deeply studied by several eminent vegetable physiologists, particularly Persoon, Fries, and Greville. It does not appear that Linnæus had paid much attention

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to Fungi; in his ten genera he has not described more than ninety-four species: at present more than four thousand species have been described, and the genera allowed amount to nearly three hundred; but still their anatomy and modes of reproduction are involved in considerable obscurity, and some fanciful theories have been the consequence. By some, Fungi have been considered of meteoric formation, to spring up in particular states of the atmosphere, particularly after storms; the advocates of equivocal generation place great reliance on the production of the Fungi in favour of their theory, but it has been seen that the sporules are exceedingly small and buoyant. May they not be wafted away, and remain suspended in the atmosphere? and may not storms or particular winds, or rains, or even alterations in the electric state of the air, be the means of their finding a spot favourable for their vegetation? By some, the parasitic Fungi, which infest a variety of plants, have been considered as merely a disease of the cuticle or tissue; of this nature is the smut in wheat: that pest, the dry rot, is evidently effected by the growth of Fungi, which vegetate luxuriantly on the surface of the wood, while they penetrate and destroy the texture of the whole mass. Pl. xvii. contains the forms of some of the most remarkable and differently constructed Fungi. Fig. 1, ***Amanita muscaria***, Persoon. Fig. 3, the pileus, or part containing the sporules of ***Merulius lachrymans***, one of the Fungi which cause the dry rot; its usual form is dry, cottony, fibrous vegetation, which does not produce fructification except in favourable situations. Fig. 2, ***Agaricus mollis***, which is an exception to the general rule of plants of the genus having stems, as fig. 4 is of a *Boletus* with a stem. Fig. 5, ***Dædalea gibbosa***, one of the Tribe of *Boleti*, fixed, as they usually are, by the side to a tree. Fig. 6, ***Hydnum coralloides***, an unusual form of the genus. Fig. 7, ***Clavaria rugosa***. Fig. 8, ***Morchella esculenta***, Persoon, the Morel, used, when dried, in sauces. Fig. 9, ***Peziza aurantia***. Fig. 10, ***Tremella mesenterica***. Fig. 11, ***Batarrea phalloides***, Persoon. Fig. 12, ***Nidularia campanula***, which consists of a leathery cap resembling a bird's nest; it contains several leticular bodies which contain the sporules. Fig. 13, ***Xylaria hypoxylon***. Fig. 14, ***Sphæria papillosa***. Fig. 15. ***Lycoperdon bovista***. Fig. 16, ***Geastrum stellatum***. Fig. 17, ***Trichia denudata***. Fig. 18, ***Mucor stercoria***. Fig. 19, ***Aspergillus pennicillatus***: *b*, the same magnified. Fig. 20, ***Tubercularia vulgaris***. Fig. 21, ***Uredo effusa***. Fig. 22, ***Puccinea rosæ***, frequent on the under side of rose leaves.

In considering the relations of vegetables to each other in a descending series, the Fungi have generally been regarded as the lowest in the scale, but there are good reasons, as will be presently seen, for placing the ***Algæ*** below them. These, with a very few doubtful exceptions, are submersed aquatic plants, growing either in salt or fresh water, differing essentially from all the superior Tribes in receiving nourishment from the fluid by which they are surrounded without the assistance of the root. The several Tribes composing the Order differ so materially from each other in their construction that a separate description of each is necessary.

The most prominent Tribe are the ***Fuci***. All of these are marine plants, composed of a frond of a variety of texture, fixed by a root to rocks and other substances; the whole plant is composed of cellular tissue, but arranged so as to form, occasionally, a hard, horn-like, fibrous structure: some species are furnished with leaves which have a midrib. A remarkable peculiarity in the structure of the Fuci is the air-vessels with which many are furnished. ***F. vesiculosus***, pl. xv. fig. 17, one of the most common of the sea-weeds on our coast, is an example; in some the frond is expanded to an undefinable form, and without any midrib, and is almost of a cartilaginous nature, as ***Halymena edulis***, the dulse, fig. 13: this is almost the principal food of many of the poorer inhabitants of sea-coasts, especially in Ireland.



The fructification consists of tubercles contained in distinct receptacles or imbedded in the frond, and containing dark-coloured seeds, or sporules, surrounded with a pellucid limbus which escapes by a terminal pore: sometimes the fructification is terminal, and the sporules are disposed in a radiating form in a receptacle filled with gelatinous filaments; sometimes the sporules are contained in tubercles on the surface of the frond, as fig. 12, ***Spherococcus mamillosus***, the Carrageen Moss, lately much used as a medicine. Sometimes the fructification forms sori on the frond, as in ***Delesseria punctata***, fig. 14.

The Fuci are remarkable for the prodigious growth they sometimes reach. ***Lessonia fuscescens*** attains thirty feet in length with a trunk eight or nine inches in diameter. It is said that ***Macrocystis pyrifera*** is found from five hundred to one thousand five hundred feet in length; at the base of each leaf is an air-vessel, by which it supports itself in the water.

The great variety and elegance of the forms of the Fuci, the brilliant colours of many species, and the curious construction of the reproductive organs, of which some of the most interesting are beautifully figured in ***Algæ Britannicæ*** of Dr. Greville, conduce to make the study of these plants a pleasing employment to those who reside on the sea-coast, and have leisure

Of the genus ***Ulva*** of Linnæus, which he characterised as containing those Algæ whose fructification is contained in a diaphanous membrane, most of the species have been distributed into other genera. The genus *Ulva* is still retained, and is composed of those species which have the fruit in the form of minute granules arranged in fours, in a membranous frond of a green colour, ***U. lactuca***, pl xv, fig. 10, whose brilliant green fronds enliven almost every part of the sea shore, is an example. ***Zonaria pavonia***, Agardh, ***Ulva pavonia***, Linn., fig. 15, is a beautiful species found on the shores of Dorsetshire and Devonshire.

Arranged among the Algæ is the curious genus ***Nostoc***; it consists of a gelatinous, variously-formed frond, filled with moniliform filaments, the articulations of which, when separated, are the sporules: this and several closely allied genera, as *Tremella*, *Palmella*, &c., should be perhaps arranged with the Lichenes, to which they bear a considerable resemblance; as some of them, when exposed to the sun, produce shields.

The ***Confervæ***, or as they are now styled, ***Confervoideæ***, being one of the grand divisions of the Algæ, consist of plants abundant both in salt and fresh water, composed of articulated filaments, either simple or branched. These sometimes inosculate by the means of transverse tubes, either two filaments together, or many forming a sort of network; the fructification usually consists of sporules contained in granular masses, or sporidea, sometimes in capsules external to the filaments.

This Tribe deserves the closest investigation of the Physiologist, and is probably the best starting point in his course of study of the animal or vegetable crea-

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tion. Here we observe a union of the two. There are some of the Cuofervæ which the most acute Naturalists bave had a difficulty in deciding whether they should be placed in a *Systema Naturæ* as animals or vegetables.

It is now foond that organized Beings are not connected with each other by a series or chain of natural affinities, as was supposed by Bonnet and others, but that they form groups, the central individual of each of which is considered to be that which differs most materially in form from a similarly circumstanced individual of an adjoining group: these individuals are termed the types of the group. As we recede from the typical form and approach that of surrounding groups, the forms are termed *aberrant;* when we have arrived at what may be considered the outside of the group, we find individuals possessing a considerable affinity to some at a certain point of a neighbouring group; thus the geaus *Andræa* among Mosses is closely allied to the *Jungermanniæ.* These groups consist of Classes, Orders, Families, Genera, orany natural division; between the larger of these we observe small groups possessiog an affinity to the adjoining large groups; these are termed *osculant.* Now as we find these affinities between the confines of groups pervadiog the whole range of organized Beiugs, it may very naturally be expected that an affinity between the eonfines of the large groups of animals and vegetables would be consistent witb the unity of desigu every where apparent in the works of the Creator; and it really appears to be not only a theoretical but a certaiu truth, that the Confervæ and animalcula are osculant groups connecting the two grand divisions of animals and vegetables.

The genus *Oscillatoria* of Vaucher eonsists of plants possessing locomotive powers, which was his reason for so naming the genus; an almost constant oscillating motion may be observed in the filaments. But the most remarkable connection of animals with vegetables is to be found among some of the species of the division *Diatomaceæ* of Dr. Greville. The genus *Diatoma* is composed of plants of a strap shape, with very short articulations; these separate into parcels. Pl. xv. fig. 1: *a*, the filaments of the natural size; at *b* is a portion separating the articulations, which, in parcels of two, three, or more, but particularly when single, possess very evident locomotive properties; the direction of the motion is frequently changed in so remarkable a manner that no other cause than volition can be assigned for it. Some species of this eurious Tribe are undoubtedly the animals classed by Muller in his genus *Vibrio* of the *Animalcula infusoria*, and are so very similar in form to some of the species of the genus *Echinella*, especially *E. fasciculata* of the Scottish Cryptogamic Flora of Dr. Greville, that they probably are the same; so uncertain is the true situation of these Beings that they are placed by Botanists among plants, and by Zoologists among animals. In a *Natural History of Animalcules* lately published, the writer has rather unceremoniously, without acknowledgment, inserted the geuera *Gomphonema* of Agardh, and *Echinella* of Dr. Greville, being their Confervæ, his Animalcula.

Already many eurious facts, which tend to prove the near connection, or rather the identity, of some of the Algæ and the lower Tribe of animals, have been recorded; of these one of the most remarkable is related by M. Franz Unger of a species of the geous *Vaucheria* of Decandolle, the *V. clavata*. He observed the terminal vesicles, when at maturity, burst, the seed or sporule wheo free swam about witb very great activity, in all respects like an animal endowed with voluntary locomotion; after about an hour it began to change its form and colour, lost its apparent or real animality, and became stationary; in a short time it put forth a radicle, then a stem, fixed itself to the nearest substance, and in about eleven days bore fructification in its turn. These singular observations were repeated many times by M. Unger with the same result. It is much to be desired that those who possess microscopes and leisure would follow up these interesting discoveries.



The reproduction of some of the Confervæ is involved in much mystery; their filaments are soon formed in distilled water, if exposed to a warm atmosphere and light, and it is even affirmed, if sealed up from the influence of the atmosphere. The doctrine of spontaneous generation is so much at variance with what has been discovered of the laws of nature and the uniformity of their operation, that it has received but little encouragement. It is to be observed, that the reproduction of the lowest Tribes of animals totally differs from that of those of a higher organization, and future discoveries will probably prove an identity with the reproduction of some of the Confervæ. There are many species of animalcules which are propagated by repeated division; among these a species of the genus *Gonium* separates into sixteen individuals, each of these when at maturity into sixteen more. There appears to be some connection of the causes by which the apparently spontaneous Confervæ are produced, and the countless millions of animalcules which may be found after a few days in distilled water to which decaying vegetable matter bas been added.

### *Of the Products of Plants.*

Perhaps the most surprising among the phenomena of the vegetable economy is the products of plants, so various in their kind, so important in their uses, and affording so great evidence of design. Could any Physiologist unacquainted with the products of plants, and reasoning from what he could observe of their organization, have expected that, of different seeds, sown in the same soil, one should grow to a plant producing an abundance of gum soluble in water, another a resin not soluble in water but in alcohol, another wax not soluble in water or alcohol, one seed producing a plant abounding in wholesome food, another in deadly poison, one affording alkali, another acid, some producing colouring matter of almost every tint, others medicinal remedies for almost every disease?

In treating of their products, plants may be considered as laboratories, in which most extensive series of chemical combinations and decompositions are effected; and, as has been observed before, that water and air are the principal agents required for the growth of plants, so we find that the elementary principles of water and air, as oxygen, hydrogen, nitrogen, and carbon, are also the most abundant of the elements into which the products of plants can be resolved; three of these, and sometimes all four, in various quantities, forming more than ninety-five parts out of one hundred of every vegetable product.

Of these products the most important in its value to Man, as forming the principal support of a very large proportion of the buman species, is *farina*, or meal; it is produced from the seeds, roots, and even stems of a great variety of plants; wheat, barley, oats, rice, maize, and the roots of potatoes form the bulk of the supply.

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It is afforded by many roots, as *Dioscorea sativa*, the Yam. *Iatropha manihot*, although a poisonous plant, affords the tapioca and cassava so much esteemed in the West Indies; it is prepared from the root. It is remarkable that the roots of several poisonous plants yield wholesome farina, as several species of *Arum*. Arrow-root is the produce of the roots of plants of the genus *Maranta;* sago of the pith of *Sagus farinifera*, and *Phœnix farinifera*, both Palms.

Farina, by a simple manipulation, is separable into two substances differing in their chemical properties: the most useful is known by the name of *starch*, which is insoluble in cold water, but at a temperature of from one hundred and sixty to one hundred and eighty is readily soluble. The chemical elements of starch differ very little from sugar, into which it may be converted. By a chemical process starch has been made into sugar, the sugar weighing one-tenth more than the starch employed, the water required in the crystallization producing the additional weight. The other ingredient of farina is *gluten;* it is nearly insoluble in water, and contributes much to the nutritious properties of farina: the wheat of the South of Europe is found to contain a large portion of gluten, and is in request to make macaroni and vermicelli. One hundred parts of barley contain eighty parts of starch, six of gluten, seven of sugar, and seven of husk; a considerable portion of the starch of barley is converted into sugar by the operation of malting, during which process it absorbs oxygen and evolves carbonic acid.

Sugar is contained in many plants, but the chief supply is from the Sugar-cane, *Saccharum officinarum*, a plant of the Grass Tribe, the expressed juice of which after boiling separates into the sugar as it is imported, and molasses or treacle, which is sugar in combination with the fecula. What is called moist sugar contains a portion of molasses, which occasions its brown colour, and from which it is freed by the process of the sugar-baker; when perfectly white, or in the state of white sugar-candy, it is pure. Sugar is yielded in considerable quantity by the Sugar Maple, *Acer saccharinum;* from Beet-root, *Beta vulgaris;* from all ripe fruits, especially dried Grapes and Figs, on which it forms an incrustation.

*Gum* exudes spontaneously from the surface of plants; it is at first fluid, but by the action of the air gradually hardens. Gum Arabic, which may be considered as gum in as pure a state as it can exist, is produced from *Acacia Senegalensis*, native of Africa; gum tragacanth from *Astragalus Creticus*. The gum produced on Plum and Cherry trees is very similar in its properties to gum Arabic, but is more easily acted on by the moisture of the atmosphere.

The extracts of *colouring matter* from plants are very numerous: they are usually obtained by maceration or boiling, after the plant has been, by some mechanical process, reduced to small particles by division. One of the most valuable properties of the colouring matter of vegetables is its chemical affinities with various substances, especially with flax or wool; with the latter it enters into intimate combination, also with the fibres of silk. Woollen and silk manufactures take a deeper dye, which is more permanent than that of cotton or linen.

Of *red* colours, the most beautiful is that afforded by cochineal, which, although obtained from an insect, is originally furnished by a vegetable, the *Opuntia cochinillifera*. An inferior red, but very extensively employed, is furnished by the *Cæsalpinia crista* and *Braziliensis*, the Brazil wood and Braziletto of commerce. Another valuable red dye is Madder, which is obtained from the roots and stems of *Rubia tinctorum*. *Rocella tinctoria*, the Orchal, a Lichen from the Canary Islands, affords a fine red.



*Blue* is principally obtained from the *Indigofera tinctoria*, which is cultivated in the neighbourhood of Guatemala, and latterly in the East Indies to a great extent, and forms a very valuable article of Commerce. When the plants arrive at maturity, the leaves are gathered, immersed in vessels filled with water and undergo fermentation; after which blue flakes of sediment are precipitated, which are made up into small lumps, dried, and packed in skins, and become the bales of indigo of Commerce. Indigo is soluble in sulphuric acid, which changes the colour from that called indigo to a true blue. An extract, with properties very similar to indigo, is obtained from *Isatis tinctoria*, or Woad, the plant is a native of England.

*Yellow* is chiefly obtained from *Morus tinctoria*, the Fustic of Commerce, which grows plentifully in the West Indian Islands, particularly in Cuba, which furnishes the best Fustic. Yellow dye is also extracted from *Reseda luteola*, *Genista tinctoria*, and several other plants.

*Logwood*, of which several thousand tons are annually imported, is principally used for producing, when added to sulphate of iron, the *black* dye. The nut-galls of the Oak, especially of a foreign Oak imported by the name of *Valonia*, are also used to produce black: this is produced by an extract called *tannin*, a very peculiar and useful vegetable product found in the bark of many trees, but particularly of the Oak. Tannin is considered to be the principle of astringency; it has the peculiar property of forming an insoluble compound with animal gelatine, and, in consequence of such property, is useful in hardening and converting into leather the skins of animals by the process called tanning.

The *oils* obtained from vegetables are of two sorts: one is called *fixed*, the other *volatile*. The fixed oils are usually procured by pressure: as lintseed oil from the seeds of *Linum usitatissimum;* olive or salad oil from the pericarp of *Olea Europæa;* oil of Almonds from the seed of the Almond: the mixture of these oils with alkalis form soap. Olive oil and soda form an excellent soap.

The fixed oils are divided into *fat* oils and *drying* oils. Olive oil is a fat oil; the *drying oils* are lintseed oil, expressed from the seeds of *Linum usitatissimum;* nut oil from the Hazel and other nuts; poppy oil from the seeds of *Papaver somniferum*.

*Volatile oils*, or as they are generally termed *essential oils*, are mostly procured by distillation, and sometimes by expression; they are more numerous than the fixed oils. Perhaps every plant that is fragrant will furnish an essential oil, which exists sometimes in the wood, at others in the bark, or in the leaves, or only in the corolla: oil of turpentine is distilled from the turpentine that exudes spontaneously, or from wounds made into the wood of many species of the genus *Pinus;* oil of cinnamon from the bark of *Laurus cinnamomum*, the Cinnamon tree; oil of cassia from the bark of *Laurus cassia;* attar of roses from the petals of the Rose; the odoriferous perfumes diffused into the air from the blossoms of plants are caused by the evaporation of essential oils.

*Resins* are exudations from several trees, either from natural fissures or artificial wounds. The common resin, or rosin, is what remains of turpentine after the oil is

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distilled off. Rosin when burned exhales a very dense smoke, which is collected and is called lamp-black. Resins dissolved in alcohol form the bases of varnishes; the most useful of these are gum copal and gum mastick: gum guaiacum, useful in medicine, exudes from *Guaiacum officinale*, a tree, native of the West Indies, the wood of which is the *Lignum vitæ*.

*Gum resins* are natural combinations of gum and resin; several of these are valuable drugs. The natural Order of *Umbelliferæ* is rich in gum resins which the plants yield by wounding the stems: *Ferula assafœtida*, a native of Persia, furnishes the Assafœtida; *Pastinaca opoponax*, the Opoponax; *Heracleum gummiferum*, gum ammoniac; *Bubōn galbanum*, the Galbanum. Other plants besides the Umbelliferæ yield gum resins, as *Gombogio gutta*, the Gamboge.

*Camphor* is a substance possessing properties very similar in their nature to those of essential oils: it is obtained from *Laurus camphora*, a native of Japan; also from *Dryobalanops camphora*, the Camphor tree of Sumatra.

There are several plants that produce *wax* not differing in quality from that manufactured by bees, as that contained in the berries of *Myrica cerifera*; but the most remarkable is the *Ceroxylon andicola*, native of the forests of the Andes, the Wax Palm described by Humboldt; the trunk has a considerable coating of wax which is collected by the natives and used for candles and other purposes.

There are a great variety of *extracts* which are obtained from plants of very important uses in medicine: they are soluble in water, and the late improvements in the Science of Chemistry have enabled chemists to procure them in great purity. Some of the most valuable of these are *quinia*, the sulphate of which is *quinine*, the febrifugal qualities of which are well known: it is extracted from the bark of several species of the genus Cinchona. There are several other genera that contain this principle, and are consequently in request by the natives of the Countries where they are indigenous; *rhubarbia*, or the chemical principle of Rhubarb, is contained in the roots of several species of the genus Rheum: morphia, or the narcotic principle, is extracted from Opium, which is an exudation produced by wounding the stems of *Papaver somniferum*. The active principle on which some of the most valuable cathartics depend is called *cathartin*; it has been extracted from the Senna of Commerce, which is the leaves of *Cassia senna*: the leaves of many other trees of the natural Order *Leguminosæ* contain cathartin in variable proportions. A peculiar alkaline principle called *emetia*, or *emetin*, is extracted from the root of *Cephælis ipecacuanha*. The bitter principle employed in medicine as a tonic is usually extracted from several species of the genus *Gentiana*: it is the *Columbo* of the druggist. Many other plants possess the bitter principle in abundance; as *Humulus lupulus*, the Hop, *Quassia simaruba*, the wood of which is intensely bitter, and was formerly used by brewers during a scarcity of Hops. The Simaruba bark of Commerce is the bark of *Simaruba versicolor*.

There are several *vegetable acids* that abound in the plants in which they are found. The *Oxalic acid*, or as it was called, the Salt of Sorrel, when pure, is crystallized, and in that state is dangerously poisonous; but the plants that contain it may be eaten in moderation with impunity: it exists in *Rumex acetosella*, Common Sorrel, *Oxalis acetosella*, Wood Sorrel, both natives of England, and in the stalks of several species of the geous *Rheum*, the Rhubarb. *Citric acid* also crystallizes; it exists in considerable quantity in the Lime, Lemon, Shadock, Orange, and all the species of the genus *Citrus*, in which it is unmixed with any other acid, also in the Cranberry. The *Malic acid* does not crystallize; it exists chiefly in unripe Apples and Pears, Berberries, Elderberries, Gooseberries, Currants, and Plums. The *Acetic acid*, or vinegar, usually manufactured from wine or beer which has undergone fermentation, is found in several plants, though but sparingly, as *Cicer arietinum*: M. Morin has detected it in *Polypodium filix mas*. The *Pyroligneous acid* is obtained by the destructive distillation of wood after all matters that it contains soluble in water or alcohol have been extracted. *Gallic acid* is found in the gall-nuts of the Oak. *Benzoic acid* is aromatic and volatile; it is obtained from *Styrax benzoe*, a native of the Island of Sumatra; it has also been detected in the plants of the genus *Dahlia*. The *Prussic acid*, although procured principally from animal substances, exists as a vegetable acid in several plants; as in the leaves of *Prunus laurocerasus*, the Common Laurel, in the kernels of Peaches, Plums, Cherries, and particularly Bitter Almonds, in which it is supposed to exist in a proportion sufficient to render them dangerous if eaten in large quantities. The *Phosphoric acid* is found not only in minerals and animals, but also in vegetables; it has been found in the Onion. *Suberic acid* is contained in Cork.

The *alkalis* contained in vegetables are *soda* and *potass*; the former is produced in large quantities from the ashes of plants belonging to several genera which grow on the sea-shores, as *Salicornia*, *Salsola*, and particularly several species of *Mesembryanthemum*, of which the most remarkable is *M. glaciale*, the Ice plant; it grows in abundance on the sea-shores of the Canary Islands: when at maturity it is piled up and burned: the ashes are the *barilla* of Commerce, so valuable in the manufacture of soap on account of the quantity of soda it contains. Sea-weeds also furnish soda in considerable quantity; the ashes of these when burned are called *kelp*: nearly the whole population of the Orkney Islands are employed at the proper season in the manufacture of kelp. Although soda is a vegetable product, yet, as it is procured from plants growing near the sea, it is most probably formed by the decomposition of the salt or muriate of soda, which, by some chemical process carried on in the plant, is converted into carbonate of soda.

The analogies of vegetables with animals are so numerous and obvious, that they frequently force themselves on the attention of the Physiologist; yet analogies of vegetables with minerals are not wanting. That some of the *earths*, as well as acids and alkalis, enter into the composition of plants has been long known; but it has lately been discovered that several of the earths, certainly *silex* and *lime*, are produced in plants in a state of crystallization, a function usually considered of a strictly mineral character. M. Raspail has observed the silex, contained in the bark of the Bamboo and the epidermis of straw, in regular six-sided prisms, also crystals of carbonate of lime on the surface of the tubes of the *Chara*. Several Monocotyledonous plants produce acicular crystals of phosphate of lime; these are *Phytolacca decandra*, several species of *Ornithogalum*, *Narcissus*, *Orchis*, &c. The tubercles of *Iris Florentina* are incrusted with crystallized oxalate of lime; crystals

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Botany. of the same are found in *Rheum palmatum*. Many of the crystals found in plants are collected together in variously formed masses, sometimes in long slender prisms: these masses or single crystals have been termed Raphides. A very curious substance, somewhat resembling calcedony, is found in the joints of the Bamboo; it is called Tabasheer; it is chiefly composed of silex, and possesses hydrophanous properties.

*Caoutchouc*, the milky substance which, when dried, is called India rubber, and has lately been introduced in the manufacture of water-proof articles of clothing, is found more or less in abundance in *Cecropia peltata*, *Hævea caoutchouc*, *Ficus elastica*, *Artocarpus integrifolia*, and others, particularly those belonging to the natural order Euphorbiaceæ.

The tenacity of the *fibre* of some herbaceous plants is a property of great and extensive benefit to Man: the use of Flax, which is the prepared fibre of the stem of *Linum usitatissimum*, is of great antiquity; some of the envelopes of the mummies of Egypt have been found to be manufactured of it. A Flax used by the natives of New Zealand, made from *Phormium tenax*, has lately been imported into Europe; Hemp, of which cordage is made, is the fibre of *Cannabis sativa*: the fibres of several other plants are used for cordage, especially those of the Agave, in South America.

One of the most important of vegetable products is the *wood* of the stems and branches, and the quantities required by civilized nations is surprisingly large. Of the wood afforded by the genus Pinus, of which the immense forests of North America and the North of Europe principally consist, the importation in the various descriptions of timber, planks, deals, &c., forms a considerable branch of British Commerce. Of Oak, so valuable to the ship-builder, that of England is the most esteemed; large quantities of an inferior sort are imported from Canada; the Oak of the North of Europe is known by the name of wainscot; Mahogany, the wood of the *Swietenia mahagoni*, is imported from Honduras, San Domingo, and Cuba; that of Jamaica, whence it first came to England, is nearly exhausted: in the year 1831, 20,000 tons of Mahogany were imported into Great Britain, a quantity equal to about 100 cargoes. A spurious sort of Mahogany, the produce of *Swietenia Senegalensis*, has lately been brought from the river Gambia in Africa. The Rose-wood, so much employed in the furniture manufacture, is the wood of a species of Bignonia, growing in Brazil. Havana Cedar, imported from Cuba and sometimes from Honduras, is from the *Cedrela odorata*; that lately imported from Australia, from the *Cedrela toona*; the sweet-scented Cedar, with which black-lead pencils are cased, is from the *Juniperinus Virginiana*; a harder sort, with the same scent, is the *Juniperinus Bermudiana*, growing in the Bahama Islands. Within the last few years a very large importation of a wood called African Teak, from the neighbourhood of Sierra Leone, has taken place; it is of great value in ship-building, and has very much superseded the use of Oak, being very close and durable: this importation will be of great benefit, as it will allow our forests to recover the demand which has been made on them so largely for many years past.

These are but a few of the most useful products of plants. It would far exceed the limits of this Treatise to give even a bare notice of all, indeed it would not be possible to render the catalogue complete. Fresh discoveries of valuable properties in vegetables are continually being made; (how many during our recollection!) Botany. yet, of more than 100,000 species of plants that have been described, but a small proportion are at present used by Man. Many important uses, doubtless, lie undiscovered; the bounties of Nature are inexhaustible, and quite adequate to the increasing wants of mankind as they advance in civilization.

### *Of the Irritability of Plants.*

The phenomena which comprise the motions observed in plants, either apparently spontaneous or caused by external excitement, are so various that there is a considerable difficulty in assigning for them causes which assimilate in their character. Light is undoubtedly an important agent in some of the motions, but it probably has little or no effect in others; a vitality of a higher order than that generally considered to belong to vegetables, and closely approaching to or perhaps being identical with animal life, seems necessary to account for the irritable properties of some plants; indeed, ever since these motions have been observed, the term *sensitive* has by common consent been applied to them.

Light is an essentially important agent in the growth and health of plants; deprived of it they soon languish and die; but it is its stimulating powers in causing some of the motions of plants that we have now to consider. The "prolapsus plantarum," or sleep of plants, is a very remarkable phenomenon, undoubtedly caused by the stimulus of light; it is most observable in plants with compound leaves, as in the genera Acacia, Mimosa, &c.; the leaflets, which were expanded during the presence of daylight, as darkness comes on, fold together closely in pairs, the petiole becomes recurved close to the stem of the leaf, as if furnished with a joint; as daylight approaches, the petiole rises and the leaflets are again expanded. It is not only compound pinnate leaves that are thus acted on—the leaves of several plants, as those of the genus Oxalis, hang down during the darkness: the flowers of many plants are also subject to the stimulus of light, as those of the Crocus, which expand under the influence of sunshine. That it is not heat but light that causes the expansion is evident from the experiments of M. Bory St. Vincent, who caused the flowers of some Mesembryanthema to open by means of a powerful light artificially produced by lenses without sunshine. M. Decandolle found that he could induce some plants to acknowledge an artificial day and night, by alternate exposure to darkness and the light of candles. Although it is obvious from these experiments that the opening and closing of many flowers depend on the stimulus of light, yet the effects produced are often various, and even of a contrary nature. The flowers of some plants are closed all the day and open in the evening; this is the case with those of the genus Œnothera, Silene, and some of the Cacti, of which the night-blowing Cereus is a familiar example. The genus Mesembryanthemum presents a series of phenomena dependent on the action of light: some of the species unfold their blossoms early in the morning and close at noon; some open at noon and close in the afternoon; others, as *M. pomeridianum*, open about four o'clock and close at eight; *M. noctiflorum* unfolds about eight and continues open several hours; and it is remarkable that the species last mentioned is scentless during the day, but highly fragrant when expanded. Yet that this variety of opening and closing is evidently



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the effect of the stimulus of light is proved by the flowers of all remaining closed during a cloudy, dark day.

Those flowers which open and close as they are influenced by a dry or moist state of the atmosphere, are probably only affected in the same manner as the substances used in hygrometrical machines, the bases of the petals or leaves of the calyx expanding or contracting as the air is dry or moist.

The motions which are evidently caused by a vital irritability, and which with universal consent have been termed sensitive, are so wonderful, and seem to require an organization so nearly allied to that of animals, that an inquiry into their nature and apparent analogy to animal motion is one of the most interesting that can engage the attention of the physiologist.

Several species of the genus *Mimosa*, as *M. pudica*, *sensitiva*, *casta*, *viva*, &c., are remarkable for the motions of their leaves and even leafstalks; these plants have elegant pinnate leaves; if one of the leaflets is slightly touched, that and the opposite leaflet fall down or close together, into the same position as that they remain in during the night; in about a second of time the next lower pair of leaflets collapse, then the next pair, and so on until the pair nearest the base of the leaf is closed; then the leafstalk falls down as if furnished with a hinge at the point of its union with the stem. In a short time the leaves begin gradually to recover their expansion, and the leafstalk its usual elevation, the recovery being sooner or later according to the vigour of the plant, the warmth of the atmosphere, or time of the day, the morning or noon being most favourable to its developement; towards evening the vigour of the plant abates, as it is then approaching the period of its natural rest.

The *Dionea muscipula*, or Venus's Flytrap, is a native of the banks of rivers in North Carolina; it is furnished with leaves shaped like a battledoor, which proceed from the root and lie flat on the ground; at the apex of each leaf is a circular appendage furnished with ciliæ, the points of which incline upwards. A very slight stimulus applied to the midrib of this circular appendage causes the sides to close in the manner of a rat-trap, and the teeth to seize any object that may be present; even the foot of a fly touching the midrib is sufficient, and the force is such that the fly is crushed to death; if a straw or small stick is enclosed, it cannot easily be extricated without injury to the teeth: after a short period the circular appendage recovers its usual position. Mr. Knight, to whom the Science of Botany is much indebted for his valuable experiments, conceiving that the flies seized and detained by the Dionea were beneficial to its welfare, placed some portions of animal muscle on the leaves of a plant of the Dionea, and he found, on comparing it with other plants, that its growth and vigour were evidently promoted by the animal substance.

In Dr. Withering's Systematic Arrangement of British Plants, vol. ii. p. 318, is an account of several of the species of the genus Drosera or Sundew having irritable properties, by which their leaves have the power of seizing small insects; these are first detained by the glutinous substance contained in the glandules with which the surface of the leaves is covered, and the leaf then folds over the insect.

The irritability of plants is not confined to the leaves; the stamens and styles furnish some remarkable instances. The stamens of the *Berberis communis*, or Common Berberry, lie on the petals, the concave tips of which shelter the anthers; if a slight stimulus, as any pointed instrument or the foot of an insect, touches the inner side of the filament near its base, the stamen starts from its position forwards and the anther strikes against the stigma; no other part of the stamen, except the upper side of the filament near the base, which is the part most likely for the insect to touch, is susceptible.



The style of *Stylidium glandulosum*, a native of New South Wales, is inclined at a considerable angle from the perpendicular, so as to lie nearly on one side of the corolla; if the stigma be slightly touched, the style starts back as if furnished with a hinge at its base, till it is inclined on the opposite side of the corolla, and thus gradually recovers its first position.

There is an astonishing instance of irritability, in which the stimulus of touch, as in the above-mentioned cases, is not necessary. The *Hedysarum gyrans*, a native of the banks of the river Ganges, and now cultivated in our collections, is furnished with ternate leaves; the lateral leaflets are small, and when the temperature of the green-house is one hundred degrees or more, are in continual motion. This motion consists of periodical starts, somewhat similar to the second hand of a clock; the leaf is at one time with its apex elevated to a considerable angle, it then descends by continued starts till it is as much depressed, then again rises; during a series of elevation and depression, the apex moving in an ellipse, this movement is best observed when the sun is shining strongly, but it does not appear that light is the stimulus required, for if the temperature of the green-house is sufficiently elevated, the motion continues during the night.

Whether the irritable and evidently vital motions that have been described are the result of, or are accompanied with sensation, is an inquiry that naturally presents itself; till further discoveries are made in the anatomy and physiology of vegetables, we can only reason hypothetically, with analogy for our guide. In the animal economy it is as difficult to conceive irritability without the presence of a nervous system, as it is to suppose locomotion without a system of muscles. In some recent researches of comparative anatomists, nerves have been discovered in animals of very simple organization, and in which they had not previously been supposed to exist. It is now believed that the very lowest animals, even the *Animalcula infusoria* and the Polypes, possess nerves, though not at present evident to our senses. Almost daily experience proves that we must not deny the existence of nerves in animals because they have not been discovered; indeed, we cannot deny it, if we reflect on the unity of design so apparent through the whole range of organized creation, where we constantly find analogous causes producing analogous effects. Some of the most important discoveries in Science have resulted from predictions necessarily arising from the consideration of this unity of design, of which the combustibility of the diamond, predicted by Newton, is an example. In animals we cannot suppose vitality without sensation, or sensation without a nervous system; may we not, therefore, safely predict the discovery of a nervous system in plants, when we reflect on the numerous analogies which we find in the physiology of animals and vegetables, especially in the economy of their reproduction?

Some attempts have been made to account for the irritable motions of plants, as well as the circulation observed in *Chara*, *Hydrocharis*, &c., by the supposition

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that they were caused by Galvanism. Since the discovery of this important agent, it has been repeatedly called out as a sort of forlorn hope to account for natural phenomena for which no other cause could be discovered. An able vegetable physiologist, who does not seem to consider that plants possess sensation, suggests that the motions observed may be something similar to those of the muscular fibrs of animals when exposed to the action of the galvanic fluid after the sentient principle is gone; but in this case of the muscular contractions of animals caused by galvanic influence, is the sentient principle gone? So intimately connected and so inseparable seem vitality and sensation, that where there are the remains of vitality which may be excited by galvanism conveyed to the muscular fibre by the medium of the nerves, is it not more reasonable to suppose that there are also the remains of sensation?

The experiments of M. Marcet of Geneva, on the effect produced on plants by different poisons, are in favour of their vitality being analogous to the nervous vitality of animals. It has been long known that the irritative and corrosive poisons are totally different in their operation on animals from those whose principle is narcotic; the former cause the death of the animal by corroding and destroying the vessels, the latter by paralyzing the nerves. Now the results of the experiments of M. Marcet, which have been repeated and varied by M. Macaire and others, prove that the effects of these poisons on plants have a wonderful coincidence with their effects on animals. It may readily be supposed that the corrosive poisons, as arsenic, corrosive sublimate, acids, &c., would destroy the life of a plant; but if we do not allow plants to possess some kind of system of nerves, can we expect they will be injured by those vegetable poisons that destroy animals by paralyzing their nerves? Yet such is the fact. Young plants, as beans, &c., were removed from the earth in which they were growing and placed in water; it was found they would continue in health six or eight days; but when a weak solution of opium, or belladonna, or laurel leaf, was added to the water in which the plants were placed, their life was destroyed in a few hours, and all attempts to revive them, by removing them into pure water or earth, were ineffectual. If a leaf of the sensitive plant is cut off with a pair of scissors, and allowed to fall into water, the leaflets collapse by the contact of the scissors, but will afterwards expand; when fully expanded, if touched with a finger they again collapse. This may be repeated for several days, the leaf retaining its life so long; but if, when it is cut off, it is allowed to fall into water containing a small quantity of vegetable narcotic poison, the leaflet will expand, but will not again exhibit irritability even when removed into pure water, its life being extinct.

Very little progress has yet been made in the discovery of the organs by which these movements are effected; some have supposed that the spiral tubes, whose mechanism seems well adapted to the purpose, are employed. It has been observed, that they abound in those parts of irritable plants in which the movements take place, but they certainly are found plentifully in plants in which no movements have been observed; yet it should be considered, that we frequently find that one set of organs in the more simply organized beings perform several functions; as for example, the ciliæ of the animalcula, which are not only the organs of respiration but of locomotion. The whole subject still remains in considerable obscurity, and presents a wide field for research.

Some Botanists have supposed that plants are endowed with a low degree of instinct, or with some analogous faculty, and some curious facts have been observed that seem to favour the supposition.

Climbing plants furnished with tendrils, and others with hooks or other organs for taking hold of substances, seem to seek out for the most favourable support. Among the noble collection of Palms in the conservatory of Messrs. Loddiges at Hackney was one furnished with hooks near the apex of the frond, evidently designed for attaching it to the branches of trees for support when growing in its native forest. The ends of the fronds were pendent, but one nearest to the rafters of the conservatory lifted the end several feet to fasten to the rafter; none of the other fronds altering their position, they could not have reached the rafter had they attempted to do so.

Travellers have frequently met with instances of trees growing on one side of a ravine where there was too little soil on the rocks for their favourable growth, with a root projected across to the opposite side of the ravine where there was a greater supply of earth, into which the root had penetrated, and the tree had thus obtained a supply of nourishment.

There are several plants, such as the species of the genus Pandanus or Screw Pine, which have the lower part of the trunk elevated several feet above the ground, being supported by the roots. As the plant increases in size, and consequently in weight, fresh roots project from the lower part of the trunk above those first formed, and reach the earth; if the plant happens to lean from the perpendicular, roots are produced from the side of the trunk nearest the earth, at some distance above the other roots, which, when they have penetrated the earth, form supports in the same manner as we shore up an inclined building in danger of falling.

Connected with this subject is the curious fact, first observed by Linnæus, that many plants furnished with spines for their defence in their wild state lose them by cultivation, being no longer necessary to protect them from the attacks of animals. He says, "The most fierce animals by culture are made surprisingly tame, and we also see the same things in plants very common."

### *Duration of Plants.*

There is a much greater difference in the longevity of plants than in that of animals; some of the Fungi exist only for a few days, some of the forest trees for thousands of years.

Phenogamous plants are either annual, biennial, or perennial.

An *annual*, in one season, flowers, produces its fruit, and dies, and in general no care can preserve its existence for another season; there are, however, some few that become perennials if removed to a warmer climate, and some perennials become annuals in a colder climate: the Sunflower, *Helianthus annuus*, is a good example of an annual.

A biennial produces a stem and leaves only during the first year of its growth, flowers and fruit the second year, and then dies. *Campanula medium*, the common Canterbury Bell of the gardens, and *Digitalis purpurea*, the Foxglove, are familiar examples.



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A perennial is of more than two years' duration; all trees, shrubs, and a large proportion of herbaceous plants, are perennial; their duration is various and uncertain, being influenced by situation, soil, and climate. The age of trees may be ascertained very nearly by measuring their circumference at four or five feet from the ground, and dividing the number of feet by 6; this will give the semidiameter or distance from the centre to the outside with sufficient accuracy, after allowing something for the thickness of the bark; we must have previously ascertained how many lines of yearly growth that description of wood usually exhibits in an inch. Thus the wood of the Lime tree contains about six lines in an inch; if the circumference of a Lime tree is found to be six feet, the semidiameter will be one foot, or eleven and a half inches making allowance for the bark, the age will consequently be sixty-nine years; a Yew tree has about twelve lines of yearly growth in an inch, consequently a tree of six feet circumference will be one hundred and thirty-eight years old. Evelyn, in his *Sylva*, mentions a Yew tree growing in his time in Braburne church-yard in Kent, that he measured, and found the circumference to be fifty-eight feet eleven inches; this will give the age one thousand three hundred and eighty years in this way. Decandolle has estimated the ages of some individual trees as follows:

| | Years. | | Years. |
|---|---|---|---|
| Elm ....... | 335 | Olive ..... | 700 |
| Cypress .... | 350 | Cedar ..... | 800 |
| Ivy ....... | 450 | Lime ..... | 1076 |
| Larch ..... | 576 | Oak ...... | 1080 |
| Orange .... | 630 | Yew...... | 2588 |

But a much greater age has been assigned to some other trees. Adanson calculated that an individual of the *Adansonia digitata*, the Baobab tree of Senegal, was five thousand one hundred and fifty years old, and M. A. Decandolle considers some trees of the *Taxodium distichum* to be still older.

In this method of calculating the age of trees from the number of lines of yearly growth in a given space, care should be taken that an average should be made from several specimens, as it frequently happens that the wood is much closer on one side of a tree than on the other, and different individuals of the same species vary in density; it is very difficult, and sometimes impossible, to observe these annual circles in some of the dense and dark-coloured wood of many tropical trees, as the Lignum vitæ, &c.

There is no known method of discovering the age of Monocotyledonous plants, as they form no wood. Many of them, however, arrive at a great age; the *Agave Americana*, or great American Aloe, has the well-known character of flowering once in a hundred years, and, perhaps, some have been that time in this Country before they have flowered; but there was an instance a few years since of one in Devonshire flowering at the age of twenty-five years: in their native Country four or five years is sufficient to bring them to maturity. The *Dracæna draco*, the great Dragon tree at Oratava in the Island of Teneriffe, was considered by M. Decandolle to be several thousand years old when he visited it, and this is only an herbaceous Monocotyledonous plant without any wood in a stem forty-eight feet in circumference.

There does not appear to be any known cause for the death of a healthy perennial plant, or any assignable period to its existence. When we consider the very great age of the plants we have mentioned, it will not be thought impossible that some of the first created individuals may still exist.



Some herbaceous plants have the root only perennial, the herb dying away annually, as *Rheum palmatum*, the Rhubarb.

In the same genus we sometimes meet with species that are annuals, others biennial, and some perennials, as in Lavatera, &c.

The duration of Cryptogamous plants is in a great degree proportioned to the extent of their organization; the Fungi, which consist of mere vegetable tissue almost without arrangement, are often of only a few days' existence, while the Ferns, which approach the more perfect plants in structure, are perennial.

### *Of the Diseases of Plants.*

Plants, like animals, are subject to diseases; and physiologists have considered some of these so similar to those of animals, that the same names have been used, as tabes, anasarca, chlorosis, pernis, &c., but, perhaps, without sufficient reason. Of some of these diseases the causes are unknown, but of others they are apparent; a vitiated state of the juices, arising from extreme cold, heat, moisture, or drought, may generally be considered as the cause of the unhealthy appearances observed.

A very frequent disease is blight. It is probable that there is more than one disease included under this name, as the blight of fruit trees seems different from that of wheat. In the Spring, the cold dry East winds seem to interfere with the healthy circulation of the sap of trees which some previous warm days had stimulated, and the leaves, being thus deprived of their necessary juices, wither, curl up, and form habitations for myriads of the larvæ of insects which consume the remaining juices, or those which may follow on an increase of temperature and thus contribute to aggravate the disease. When it is considered how necessary the leaves are to elaborate the sap for the purpose of supplying the cambium so essential for the formation of the year's layer of wood and bark, we need not wonder that we find, as is frequently the case, the whole plant deranged, and if not killed, remaining in a sickly state all the Summer, and requiring the following, perhaps, more genial Spring to restore it to health; sometimes when the cold is not so severe as to affect the leaves, if we examine the blossom, we shall find the unexpanded anther dried up and without pollen, which is so essential for the production of the fruit.

One sort of *blight*, to which wheat, barley, &c., are subject, appears in the form of a reddish-brown collection of minute globular bodies formed under the epidermis of the leaf, through which it bursts; it is what the farmers call the *red rust*. It also attacks the stalk, and although it most probably weakens the plant, it does not appear to prevent the production of the grain; it is found to be a species of Fungus. Another Fungus attacks the ear; farmers call it the *red gum*. The disease called *smut*, to which grain is liable, appears in the form of a black powder, into which the whole grain of the ear is converted; this powder is supposed to be infectious, and affects the crop of the next year if any of it is retained among the grain intended for seed: it is recommended that the seed should be steeped in a solution of arsenic.

If plants are overwatered, or are exposed to long con-

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tinued rain, they are affected with a disease which has been considered analogous to the *dropsy*. Succulent plants are frequently killed by being overwatered, the whole plant becoming suddenly decomposed.

Apple and Pear trees in this Country, especially when growing in a gravelly soil, are subject to a species of *canker*, appearing in the form of brown spots, which, spreading, sometimes surround the branch, which then dies: sometimes the whole tree is destroyed.

The disease called *etiolation* causes the leaves of plants to appear of a sickly pale yellow colour, as is the case with those kept in rooms and deprived of light, whose agency is so necessary for the absorption of the oxygen of the atmosphere; plants in this state soon recover their green colour when exposed to the light of the sun.

Many of the minor diseases of plants are caused by the attacks of insects. It is probable that a previously unhealthy state of a plant is favourable to the nourishment and consequent increase of some insects, as the exudation of the gummy sweet substance called *honey dew* encourages the increase of aphides; but healthy plants are also attacked, and the result is the formation of excrescences called galls; of these several are met with on the Oak, as the oak apple, caused by a species of Cynips. Another species causes the gall nut, so useful in dyeing and in the manufacture of ink; the insect, by means of its ovipositor, fixes an egg in the under side of the leaf, the larva from which, when it is hatched, causes an irritation which induces a morbid accumulation of vegetable tissue.

### *Classification.*

During the earliest Ages mankind were acquainted with but few of the properties of plants, consequently not many species engaged their attention, and the necessity of classification was not felt; but as the knowledge and wants of Man increased, and in addition to the nutritive, the medicinal virtues of vegetables were developed, some method of arrangement became necessary, and some mode of description by which a plant could be identified.

We have but little information of the extent of botanical knowledge during the first four thousand years after the Creation; it cannot be doubted that during that period there were individuals whose attention was attracted to the vegetable kingdom, and who studied the affinities of plants, yet but very few of their observations have reached us; from Holy Writ we learn that Solomon was endowed with a knowledge of plants, and the notice, though brief, indicates that his knowledge was extensive. Hippocrates, who lived four hundred and fifty years B. C., has mentioned the uses of about two hundred and fifty plants, but has given no description by which they may now be known. Aristotle wrote an elaborate Work on animals, and another on plants; the latter has not reached us, but we have the History of plants, and the causes of vegetation, by his pupil Theophrastus, who has described about five hundred plants, and who approaches, though in a rude manner, to something like method. In the succeeding Ages, even up to the XVIth Century, scarcely any progress in classification was made, and no other than alphabetical lists were in use.

The first attempt at a general scientific arrangement was made by Cæsalpinus, an Italian, in 1583, which was soon after followed by the celebrated Herbal of our Countryman Gerard. But, with the exception of the illustrious Linnæus, no writer on plants has produced so extensive and scientific an arrangement as John Ray, the celebrated English Naturalist, born in 1628. He has described a very great number of species and varieties, which he arranged according to their duration, the absence or presence of the flower, the number of petals, the adherence or non-adherence of the calyx to the germen, the modes of inflorescence, disposition of the leaves, &c.; and although his method was afterwards much improved by Tournefort, whose arrangement produced more natural groups, and a more successful division of plants into classes, orders, and genera, yet it cannot be denied that the foundation of his arrangement was laid by Ray.

But when the Sexual system of Linnæus, founded on the number and situation of the stamens and pistils, was published, its superiority over all preceding systems was at once apparent, and it was very generally adopted. The most zealous advocates of the natural system must indeed allow that the artificial system of Linnæus gave an importance to the Science of Botany that it would not, without it, have attained; for it is probable that the many natural groups which his artificial system presents have more conduced to stimulate the efforts of succeeding Botanists to discover a natural method, than that the defects of his system have forced them, from necessity, to endeavour to accomplish so difficult but desirable a task.

Of the existence of a natural method Linnæus was fully aware, as the following observations in his *Philosophia Botanica* will prove: "Besides all the above-mentioned systems, or methods of distributing the plants, deduced from the fructification, and which may, therefore, be called artificial, there is a natural method which we ought diligently to endeavour to find out and that the system of Nature is no chimera, as some may imagine, will appear; as from other considerations, so in particular from this, that all plants, of whatever order soever, show an affinity to some others to which they are nearly allied: in the mean time, till the whole of Nature's method is completely discovered, (which is much to be wished,) we must be content to make use of the best artificial system now in use." It is worthy of remark that, from the foregoing extract, it is apparent that Linnæus was not only aware that there was a natural method, but that he seems to have had a knowledge of the affinities of natural groups, which have lately so engaged the attention of Naturalists.

The Linnæan or Sexual system, founded upon the doctrine of the sexes of plants, although confessedly artificial and daily giving way as the natural system becomes developed, is still the easiest introduction to the knowledge of the classification of plants; and in acquiring the elements of the Science of Botany, the student will accomplish his object much sooner by beginning with it: in the present imperfect state of our knowledge of the affinities of plants, he will meet with many disheartening difficulties in his progress, if he commences with the natural method.

The sexual differences of plants were known to some of the early Naturalists, as well as that the fructification depended on the fertilizing properties of the pollen, as appears from the following passage in Pliny: *Adeoque est Veneris intellectus ut coitus etiam excogitatus sit ut*

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*homine, ex maribus flore ac lanugine, interim vero tantum pulvere insperso fœminis. Hist. Nat.* lib. xiii. c. 4. But it was not till Linnæus established the doctrine by decisive experiments that it was generally understood and adopted.

As Linnæus found the stamens and pistils to be such important organs, he was naturally led to observe to what extent they were constant in number and situation in the different natural Tribes of plants, and he found them to be sufficiently regular to constitute the basis of a system of arrangement.

He divided the whole vegetable kingdom into *classes, orders, genera*, and *species*; the classes and orders, according to the number, proportion, figure, and situation of the stamens and pistils; the genera formed of groups of species with similarly constructed fructification; and the character of the species from the variations of form in the other parts of the plant, as the corolla, calyx, leaves, &c.

Thus, of those plants whose flowers are furnished with stamens and pistils, he selected all which possess five stamens; these he united into one class, which he called Pentandria; these he again divided into orders, according to the number of pistils, one pistil the order Monogynia, two pistils Digynia, &c.

The next subdivision of *genera* is of great importance, and requires considerable attention; for a genus is a natural group, independent of any artificial arrangement, but essential to every system. Before the time of Linnæus, plants of distant affinities were grouped together in the same genus, and Science is still suffering from the confusion thus occasioned. The juvenile Botanist is often deterred from the pursuit of the delightful Science for fear of being accused of an affectation of learning, if he should presume to call that a Pelargonium which the gardener calls a Geranium, or that an Agave which he sees advertised as the "Great American Aloe in blossom."

A very superficial observation will discover that a number of species is naturally arranged into a group constituting a genus, agreeing generally in habit and readily distinguishable from all other plants; as the Red and Black Currant, differing from each other in the shape and colour of the fruit, the form of the leaves, &c., yet both belong to the same genus Ribes; the same may be observed of the different Roses, Willows, &c; but the species of many genera are not so evident, and require a more particular observation.

The character of a genus is formed from the number, figure, proportion, and situation, or connection of the parts of fructification, namely, the calyx, corolla, nectary, stamens, pistils, germen, receptacle, and seed. But the Science has been much simplified by adopting what Linnæus has called the essential generic character, which consists of a description of only those parts of the fructification that are sufficient to distinguish the genus from all others in the class and order to which it belongs, without describing the other parts: thus if we find that all the species of a genus are furnished with five petals, and no genus in the same class and order has five petals, it is a sufficient generic character to say, petals five; but if other genera in the same class and order have five petals, then some other character must be added to distinguish each, always taking care, for the sake of brevity, that no unnecessary distinguishing character be employed. In most of the larger books of descriptive Botany two characters are given, the generic character and the essential generic character; the characters of the genera in our MISCELLANEOUS Division are the latter.



Although, in general, the limits of genera are well defined, yet, as many adopted by Linnæus contain distinct groups, later Botanists have formed genera of these, and have thus considerably increased the number. His plan was to distribute large genera into divisions; thus the genus Cactus he divided into

* Echinomelocacti,
** Cerei,
*** Opuntiæ.

These divisions have been again subdivided into distinct genera by later Botanists, but it is doubtful whether these repeated divisions have been of advantage to the Science; they have certainly swelled the catalogue of genera to an extent burthensome to the memory.

A *species* is an individual of a genus, and is distinguished from all the other individuals of the genus to which it belongs; thus if only two species are known of any genus, if one has serrated leaves and the other entire leaves, this is sufficient to distinguish them, but where the species of a genus are numerous, other differences must be sought for.

As the genus and species of a plant are totally independent of the system employed, whether artificial or natural, Botanists are universally agreed in applying two appellations to all plants; the first being the name of the genus, the latter the species, as *Ribes rubra*, the Red Currant, being the species Rubra of the genus Ribes; for this great improvement in nomenclature, we are indebted to Linnæus. Before his time we had such names as *Fragraria fructu hispido, Hieracium longius radicatum*, &c., being a generic name, to which was added a short descriptive character which was worse than useless, as from the number of species continually added to each genus, the same short descriptive character would suit several species in a genus.

There is still another lower division that must be noticed, but which is not considered essential to the study, namely, the varieties into which some species occasionally split; some of these are tolerably constant, others accidental, but the greater number are produced by cultivation. There are some individuals of species found growing in a wild state which vary from others of the same species; thus the *Lichnis dioica* is sometimes found with white and sometimes with red flowers, the *Digitalis purpurea* sometimes with white flowers. Of *Thymus serpyllum*, the common Wild Thyme, there are eight varieties described; one, which grows in Ireland, is without smell, yet none of these differ from each other sufficiently to afford a character to constitute a species. These varieties are of frequent occurrence, but those produced by cultivation are the most numerous and important, as Nature, assisted by the ingenuity of Man, has produced some of the most useful vegetables, and some of the most ornamental flowers: it is even supposed that the Wheat and the Barley are cultivated varieties. Most of the useful productions of the garden are, in their wild uncultivated state, absolutely useless; the art of cultivating varieties of esculent plants may be considered in its infancy, when we view the unnumbered productions of the Florist in his parterres of Tulips, Auriculas, Anemones, Pinks, &c., and the Geraniums and Camellias of the greenhouse.

But with regard to varieties, the most important consideration to the Botanist is, the probability that many

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of the adopted species are only varieties; it is an interesting but difficult question, and not likely to be satisfactorily answered—when did each individual species of plants now existing originate? That the vegetable creation has undergone great changes since the formation of the world is evident when we inspect the vegetable fossil remains of the secondary rocks; that changes are still going on, though not so apparent, is probable, if we consider the uncertainty of the limits of the species of many genera, particularly of those whose species are most numerous; as for example, several that are indigenous in the South of Africa, as Erica, Pelargonium, Mesembryanthemum, Aloe, and Stapelia; the number of species in each of these genera is from one to four hundred, they are found growing near each other, and are probably continually hybridizing. It is a fact well known to cultivators of these genera in greenhouses, that when several species of the same genus are growing together, and plants are raised from the seed, these will very frequently prove to be hybrids, a casualty to which they must be constantly liable where they grow wild. That the origin of some species is posterior to the Creation is probable, when we consider that the genus Sempervivum, containing about twenty species, is, with a few exceptions, exclusively confined to the Canary Islands, which are entirely volcanic, and of comparatively recent formation. The desire of multiplying species is unfortunately too prevalent with the present race of naturalists; they are evidently sometimes at a loss to find specific characters. Some of the varieties of the Auricula differ very considerably, and would allow of better specific characters than some of the adopted species of the leading Botanists in the genera Mesembryanthemum, Aloe, &c.

The surprising analogy which exists between animals and vegetables is in no instance more strongly indicated than in the power they have of hybridizing, and in the similarity of the extent of this power: in both cases it does not proceed beyond the limits of a genus; in both it is limited to certain genera; in neither case is the hybrid capable of perpetuating its kind by reproduction, in animals beyond a generation, or in vegetables beyond the third, or at most the fourth; a hybrid vegetable, if reproduced from seed, either reverts back to the character of one of its parents, or becomes deprived of its reproductive functions.

To the facility with which the species of some genera hybridise, we are indebted for the splendid varieties of Pelargoniums, or, as they are usually called, Geraniums, Roses, Dahlias, &c.; these can only be perpetuated by offsets, cuttings, or portions of the root. In many of the genera that are thus in the power of the florist, it is to be regretted that the original species can now be scarcely recognised; and although many of what are called new flowers are certainly ornamental, yet there unfortunately is a bad taste prevailing. If a slight variation from any favourite flower is developed, the new variety is eagerly sought after, and is sold for a higher price than a newly introduced, and, perhaps, beautiful exotic species. If the cultivators of plants would be as diligent to encourage the introduction and cultivation of some of the many thousand species that have been described in various Botanical Works, but are yet unknown in this Country, it would be of great advantage to the Science, and we should become better acquainted with their affinities, and many of their yet undiscovered valuable properties and products.

A remarkably irregular developement of the organs of fructification frequently occurs in cultivated plants, which is of considerable importance to the physiologist, as in the study of the deviations from the more regular and usual expansion of these organs he gains an insight into the economy of their structure. The flowers of many plants which are transplanted into, or are raised from seed in a richer soil than that in which they grow wild, have a tendency to produce what are called double flowers, that is, to have the stamens and even pistils converted into petals. This curious metamorphosis attracted the attention of Linnæus, who founded the doctrine, which has since received the sanction of the most eminent Botanists, that the organs of fructification are merely modifications of the leaves of the plant. On examination, it will be found that there is a gradual change in the forms of the organs from the leaves to the pistil; thus the bracteal leaves are intermediate in form between the leaves and the calyx, the calyx has many of the properties, and its structure resembles that of the leaf; in several genera the leaves of the calyx are exactly similar in form to the other leaves; in several species of the genus Mesembryanthemum the identity is very conspicuous; that the calyx leaves are modifications of the other leaves is proved by the fact that buds are sometimes formed at their bases, of which that variety of the Daisy, called the Hen and Chickens, is an instance. One or more of the leaves of the calyx of the Apple is sometimes converted into leaves similar to the leaves of the branch; these leaves remain after the Apple is formed. The difficulty that Botanists have of deciding whether it is a calyx or corolla, where only one of these organs is found in a flower, is a proof of the similarity of their character, or rather of their convertibility; that the corolla and stamens are modifications of the same organ is evident from what takes place in double flowers, as those of the Rose, Camellia, Dahlia, &c. We sometimes find a few extra petals and a corresponding diminution in the number of the stamens; some of the latter we sometimes find partially changed into petals, such as an expanded coloured filament surmounted with an anther; in very double flowers the whole is converted into petals, and the stamens and pistils have disappeared. That the opinion of Linnæus as to the identity of the rudiments of the leaf-buds and flower-buds is correct is satisfactorily proved by the fact, that if a plant that has flowered and fruited for several successive years be removed into a richer soil, flowerless branches are produced, the buds formed in the axillæ of the leaves, which would have produced flowering branches, now produce only leaf branches.

Not only the flower, but the roots, stems, and leaves of plants are subject to variation by culture, and to this property we are indebted for most of our vegetables and fruits. The roots of Turnips, Radishes, Carrots, Parsnips, &c., in their wild state, are hard, stringy, and tasteless. The stems and branches of plants are not so liable to variation as the other parts, yet there are some striking examples, as the expanded proliferous stem of the *Celosia cristata*, or Cockscomb, and the multiplied branches of the *Brassica oleracea* in the Cauliflower and Brocoli. The leaves are more subject to variation than the stem; some species allow of a considerable number of forms. The *Brassica oleracea*, besides the variety of stem, by the alteration of the leaves produces the Common Cabbage, the Savoy, the Red Cabbage,

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and the Scotch Kale; but no part of a plant is so subservient to the skill and industry of the horticulturist as the fruit; almost every season new varieties of Apples, Peaches, and Strawberries are announced. It is to be observed that the varieties of fruits are not permanent; no skill of the gardener can preserve the varieties of Apples; many of the favourite sorts are now almost unknown; the Golden Pippin is nearly gone, and the Nonpareil is getting scarce; but all cultivated varieties require constant skill and labour to prevent their return to the original form of the species. It is very probable that Wheat and Barley, if neglected, would lose their nutritious properties and revert back to the character of mere useless grasses. In the tropical climates, where the heat prevents that active industry so necessary to the culture of vegetables, nutritious and grateful fruits grow wild; but as we approach the poles, these are more sparingly produced; and the industry of man, so necessary to a healthy condition in colder climates, is called into action to cultivate those varieties which, if neglected, are constantly tending to their original useless, wild state.

*Synopsis of the Linnæan Classes and Orders.*

Class I. MONANDRIA. One fertile stamen.
Three Orders:
*Monogynia.* One pistil.
*Digynia.* Two pistils.
*Trigynia.* Three pistils.

Class II. DIANDRIA. Two fertile stamens.
Three Orders. The same as in Monandria.

Class III. TRIANDRIA. Three fertile stamens.
Three Orders. The same.

Class IV. TETRANDRIA. Four fertile stamens.
Three Orders:
*Monogynia.*
*Digynia.*
*Tetragynia.* Four pistils.

Class V. PENTANDRIA. Five fertile stamens.
Six Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Tetragynia.*
*Pentagynia.* Five pistils.
*Polygynia.* Numerous pistils.

Class VI. HEXAGYNIA. Six fertile stamens.
Five Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Tetragynia.*
*Polygynia.*

Class VII. HEPTANDRIA. Seven fertile stamens.
Four Orders:
*Monogynia.*
*Digynia.*
*Tetragynia.*
*Heptagynia.* Seven pistils.

Class VIII. OCTANDRIA. Eight fertile stamens.
Four Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Tetragynia.*

Class IX. ENNEANDRIA. Nine fertile stamens.
Three Orders:
*Monogynia.*
*Trigynia.*
*Hexagynia.* Six pistils.

Class X. DECANDRIA. Ten fertile stamens, (not united.)
Six Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Tetragynia.*
*Pentagynia.*
*Decagynia.* Ten pistils.

Class XI. DODECANDRIA. Twelve or more fertile stamens, inserted into the receptacle.
Five Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Pentagynia.*
*Dodecagynia.* Twelve pistils.

Class XII. ICOSANDRIA. Twenty or more fertile stamens inserted into the calyx, or the inner side of the corolla.
Five Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Pentagynia.*
*Polygynia.*

Class XIII. POLYANDRIA. Numerous stamens inserted into the receptacle.
Seven Orders:
*Monogynia.*
*Digynia.*
*Trigynia.*
*Tetragynia.*
*Pentagynia.*
*Hexagynia.*
*Polygynia.*

Class XIV. DIDYNAMIA. Four fertile stamens, two of which are shorter than the others.
Two Orders:
*Gymnospermia.* Seeds uncovered.
*Angiospermia.* Seeds covered.

Class XV. TETRADYNAMIA. Six fertile stamens, two of which are shorter than the others.
Two Orders:
*Siliculosa.* Seed-vessel short and broad.
*Siliquosa.* Seed-vessel long.

Class XVI. MONADELPHIA. Stamens united at their base into *one* bundle.
Nine Orders:
*Triandria.* Three stamens.
*Pentandria.* Five stamens.
*Heptandria.* Seven stamens.
*Octandria.* Eight stamens.
*Enneandria.* Nine stamens.
*Decandria.* Ten stamens.
*Endecandria.* Eleven stamens.
*Dodecandria.* Twelve stamens.
*Polyandria.* Many stamens.

Class XVII. DIADELPHIA. Stamens united at their base into *two* bundles.
Five Orders. Depending on the number of stamens, as in the Class Monadelphia.

Class XVIII. POLYADELPHIA. Stamens, united at their base into three or more distinct bundles.

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Four Orders. Depending on the number of stamens, as in the two last-mentioned classes.

Class XIX. SYNGENESIA. Anthers united into a tube, flowers compound.

Five Orders:

*Polygamia æqualis.* Each floret furnished with stamens and pistils.

*Polygamia superflua.* Florets of the disk furnished with stamens and pistils, those of the margin with pistils only.

*Polygamia frustranea.* Florets of the disk as in the preceding order; those of the margin without either stamens or pistils.

*Polygamia necessaria.* Florets of the disk furnished with stamens only; those of the margin with pistils only.

*Polygamia segregata.* Several flowers, simple or compound, each with a partial calyx, and the whole with a general calyx; the anthers united into a tube.

Class XX. GYNANDRIA. Stamens placed on the style or pillar-shaped receptacle.

Nine Orders:

*Diandria*, &c. depending on the number of stamens, as in the XVIIIth Class.

Class XXI. MONOECIA. Stamens and pistils in distinct flowers on the *same plant.*

Nine Orders:

| | |
|---|---|
| *Monandria.* | One stamen or sessile anther. |
| *Diandria.* | Two stamens. |
| *Triandria.* | Three stamens. |
| *Tetrandria.* | Four stamens. |
| *Pentandria.* | Five stamens. |
| *Hexandria.* | Six stamens. |
| *Polyandria.* | More than six stamens. |
| *Monadelphia.* | Stamens united into a bundle. |
| *Polyadelphia.* | Stamens united into several bundles. |

Class XXII. DIOECIA. The flowers furnished with stamens only, and those with pistils only, *on distinct plants.*

Eight Orders:

| | |
|---|---|
| *Monandria.* | One stamen. |
| *Diandria.* | Two stamens. |
| *Triandria.* | Three stamens. |
| *Tetrandria.* | Four stamens. |
| *Pentandria.* | Five stamens. |
| *Hexandria.* | Six stamens. |
| *Polyandria.* | Eight or more stamens. |
| *Monadelphia.* | Stamens united into one bundle. |

Class XXIII. POLYGAMIA. Stamens and pistils separate in some flowers, united in others, either on the same or distinct plants.

Three Orders:

*Monoecia.* Flowers furnished with stamens and pistils, accompanied with flowers furnished with or without stamens, on the same plant.

*Dioecia.* The different flowers like *Monoecia*, but on separate plants.

*Trioecia.* The different flowers on three separate plants.

(This class is suppressed by several Botanists, and the plants are added to some of the preceding classes.)

Class XXIV. CRYPTOGAMIA. Stamens and pistils either unknown or hidden within the plant.

Five Orders:

| | |
|---|---|
| *Filices.* | Ferns. |
| *Musci.* | Mosses. |
| *Hepaticæ.* | Liverworts. |
| *Algæ.* | Lichens, &c. |
| *Fungi.* | Mushrooms, &c. |

Appendix. *Palmæ*, Palms; now incorporated with some of the preceding classes.

*Remarks on the Linnæan Classes and Orders.*

MONANDRIA. *Monogynia* commences with an interesting Tribe of plants which compose the natural order of Scitamineæ, containing *Canna, Zingiber*, Ginger, *Maranta*, Arrow-root, *Curcuma*, the Turmerie, &c.: this Tribe has been ably elucidated by Mr. Roscoe in the eighth volume of the *Transactions of the Linnæan Society.* It is worthy of remark that the natural order Scitamineæ was first established by Linnæus, and is still retained; yet modern Botanists, when quoting the names of authors who have adopted this natural order, leave out the name of its founder: the only other plant in this order remarkable is the *Salicornia.* The order *Digynia* does not furnish any interesting plants; the genus *Chara* is now removed to the class Cryptogamia.

DIANDRIA. The order *Monogynia* contains the fragrant natural order Jasminæ, as the Jasmine, Lilac, Olive, &c.; the genus *Veronica*, of which several elegant species are indigenous in England; the fine genus *Justicia, Calceolaria*, many new species of which have been lately introduced; *Pinguicula* and *Utricularia*, interesting water-plants, composing the natural order Lentibulariæ of Richard; then follow *Rosmarinus* and *Salvia*, the Rosemary and Sage, belonging to the natural order Labiatæ. Here we find the Linnæan system at fault; the other genera of the order Labiatæ, as Thymus, Mentha, &c., are removed far off in the class *Didynamia.* The order *Digynia* furnishes another anomaly; *Anthoxanthum odoratum*, the grass that produces the fine scent in new hay, stands here separated from the other Gramineæ. The order *Trigynia* has the extensive genus *Piper*, affording the Pepper, Betel-nut, &c.

TRIANDRIA. *Monogynia* commences with the genus *Valeriana*, several species of which are natives of England. This is soon followed by a beautiful group of fine flowering plants of the natural order Irideæ, as *Crocus, Iris, Ixia, Watsonia, Gladiolus, Moræa*, &c.; then some plants of the natural order Cyperaceæ, allied to Gramineæ, as those of the genus *Schœnus, Cyperus*, which furnishes the Egyptian Papyrus, *Scapus*, &c. The order *Digynia* contains the great mass of the natural order Gramineæ, or Grasses, among which we have the Wheat, Barley, Oats, Sugarcane, Rice, Maize, and the Bamboo, which, although a grass, attains to forty or more feet in height, with a stem eight or nine inches in diameter. The order *Trigynia* contains no remarkable plants.

TETRANDRIA. *Monogynia.* This order is remarkable for containing the noble Tribe of *Proteaceæ*, composed of fine evergreens, small trees, and shrubs, with large compound flowers; they constitute a considerable portion of the vegetation of the South of Africa, New South Wales, and New Zealand: in the tenth volume of the *Transactions of the Linnæan Society* will be found an able Paper on this natural order by Mr. R. Brown. The order *Monogynia* also contains other plants with



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composite flowers, as *Dipsacus*, the Teasel. *Scabiosa*, &c.; we find here the singular genus *Pothos*, *Alchemilla*, and *Sanguisorba*. Some species of both genera are British, *Dorstenia*, yielding the Contrayerva root; several genera with verticillate leaves, as *Asperula*, the Woodroof; *Rubia*, the Madder; *Galium*, *Cornus*, Dogwood; *Santalum*, Sandal Wood, &c.

In the order *Digynia*, the most remarkable genus is *Cuscuta*, the Dodder, the species of which are parasitic.

The order *Tetragynia* contains *Ilex*, the Holly; *Potamogeton*, the several species of which form the bulk of the submersed vegetation of our pools and shallow rivers. All the described species are natives of England; indeed this order seems partial to the British soil, for, of the forty-five species that have been described, thirty are natives of Great Britain.

PENTANDRIA is a very extensive class: throughout the vegetable system we find the number five of frequent occurrence; as five leaves or divisions of the calyx, five petals or divisions of the corolla, five stamens, five cells in the capsule. In this class we meet with many natural groups constituting complete orders in the natural system.

*Monogynia* commences with *Mirabilis*, Marvel of Peru; then follow the genus *Plumbago*, and the large natural order *Boragineæ*, many of which are well-known natives of England, as *Lithospermum*, the Gromwell; *Anchusa*, the Bugloss; *Symphytum*, the Comfrey; *Pulmonaria*, Lungwurt; *Borago*, Borage; *Echium*, &c. These are followed by the beautiful *Primulaceæ*, many of which are Alpine. The genera *Primula*, *Aretia*, *Androsace*, *Soldanella*, *Cyclamen*, *Dodecatheon*, *Lysimachia*, *Anagallis*, &c., are favourites with cultivators: then we find some genera of the order *Gentianæ*, as *Villarsia*, *Chironia*, *Erythræa*, &c. To these succeed the well-marked order of *Solaneæ*, (*Lurida* of Linnæus,) all more or less poisonous, as *Verbascum*, Mullein; *Datura*, Stramonium; *Hyoscyamus*, the Henbane; *Nicotiana*, Tobacco; *Atropa*, the Belladonna; *Mandragora*, the Mandrake: part of the natural order *Convolvulaceæ*, as *Convolvulus*, *Ipomæa*, &c.: the elegant climbing *Cobæa*, the order *Epacrideæ*, shrubs with rigid leaves, natives of New South Wales: the genus *Azalea*, composed of fine flowering North-American shrubs, *Vinca*, the Periwinkle; *Nerium*, Oleander; *Tectona*, East-Indian Teak Wood: the natural order *Campanulaceæ*, containing *Campanella*, *Goodenia*, &c.; *Cinchona*, Peruvian Bark; *Portlandia*, *Coffea*, Coffee tree: the natural order *Caprifoliæ*, as *Lonicera*, Honeysuckle, &c.; *Cedrela*, the Cedar of Cuba and Jamaica; *Mangifera*, Mango; *Ribes*, the Currant and Gooseberry; *Hedera*, Ivy; *Vitis*, Vine; *Viola*, the Violet; *Impatiens*, the Balsam; the noble *Musaceæ*, whose magnificent foliage adds so materially to the beauty of tropical vegetation, comprising *Heliconia*, *Strelitzia*, and *Musa*, producing the Plantain and Banana: the interesting natural order *Asclepiadeæ*, with the corolla always contorted before it expands, containing the genera *Asclepias*, *Cynanchum*, the succulent *Stapeliæ*, *Gomphocarpus*, &c.

In the order *Digynia* are some genera of the natural order *Gentianæ*, as *Gentiana* and *Swertia*; these are followed by part of the *Convolvulaceæ*, as *Evolvulus*, *Dichondra*, &c.: then the natural order *Chenopodeæ*, *Chenopodium*, *Atriplex*, *Blitum*, &c.; *Beta*, the Beetroot and Mangelwurzel; but the order Digynia is most remarkable as containing the natural order *Umbelliferæ*, constituting a large portion of the vegetation of the Northern hemisphere; they have generally large umbels of small white flowers, the plants are herbaceous, with hollow, furrowed stems; many are deadly poisons, as *Cicuta*, the Hemlock; others wholesome articles of food, *Daucus*, the Carrot; *Pastinaca*, the Parsnep; the seeds of many are aromatic, as the Caraway and Anise seeds; others produce medicinal gums, as Assafœtida, Opoponax, and Gum Ammoniac.

The order *Trigynia* contains *Rhus*, one species of which produces the Sumach, *Viburnum*, the Guelder Rose, *Sambucus*, Elder, *Tamarix Alsine*, *Portulacaria*, &c.

The order *Tetragynia* has only one genus, *Parnassia*. *P. palustris* is an elegant British species.

The most remarkable genera in the order *Pentandria* are *Statice*, the Thrift; *Linum*, producing the useful Flax and Linseed; *Drosera*, the Sundew; *Crassula*, a large genus, with succulent leaves and brilliant flowers.

The other orders, *Decagynia* and *Polygynia*, contain no very remarkable plants.

HEXANDRIA. *Monogynia* commences with the natural order *Bromeliaceæ*, as *Bromelia*, the Pine Apple, *Pitcairnia*, &c. *Tradescantia*; but the boast of this order is the fine collection of beautiful flowering bulbous plants which it contains; among these are the genera *Hæmanthus* and *Massonia*, from the South of Africa; *Galanthus*, the Snowdrop; *Narcissus*, the Daffodil and Jonquil; *Pancratium*, *Crinum*, *Agapanthus*, *Amaryllis*; *Allium*, the Onion and Garlic; *Lilium*, the Lily; *Tulipa*, the Tulip; *Hypoxis*, *Ornithogalum*, *Scilla*, the Squill, &c. This order also contains *Anthericum*, *Narthecium*, *Asparagus*, *Dracæna*, Dragon tree; *Convallaria*, Lily of the Valley; *Polyanthes*, the fragant Tuberose; *Phormium*, New Zealand Flax; *Lachenalia*, *Aletris*, *Yucca*, so ornamental to the shores of the Carolinas; *Aloe*, *Agave*, the American Aloe of the gardens; *Alstræmeria*, *Hemerocallis*, *Acorus*, *Corypha*, *Calamus*, *Juncus*, the Rush; *Berberis*, the Barberry; *Cleome*, &c.

The order *Digynia* contains but three genera, the most remarkable of which is *Oryza*, the Rice, which is, perhaps, more abundantly cultivated than Wheat.

*Trigynia* has the extensive genus *Rumex*, Sorrel, *Colchicum*, *Sabal* and *Chamærops*, both Palms; *Hexagynia* has three genera of no note; and *Polygynia* only *Alisma*, a genus of water plants.

HEPTANDRIA is a very small class. The order *Monogynia* contains *Trientalis*; its single species is a native of England, *Æsculus*, the Horse Chestnut. *Dyginia* has but one genus, *Tetragynia* two, and *Heptagynia* three.

OCTANDRIA. *Monogynia* contains *Tropæolum*, the Nasturtium; the natural order *Onagrariæ*, as *Œnothera*, the Evening Primrose, *Epilobium*, and the elegant *Fuschia*; *Combretum*; the fine flowering East-Indian genus *Roxburghia*, *Acer*, the Maple and Sycamore; *Boronia* and *Correa*, elegant shrubs of New Holland; *Orycoccus*, the Cranberry; the large and lovely genus *Erica*, the Heath; the natural order *Thymeleæ*, containing *Daphne*, *Gnidia*, &c.

*Digynia* contains four genera, neither of which is remarkable: in *Trigynia* is found *Polygonum*, the *Persicaria*, &c. *Paullinia*, *Sapindus*, &c.; *Tetragynia* has seven genera, among which are *Paris*, a British plant with only four leaves, four calyx leaves, four petals, and a four-celled capsule, *Adoxa*, *Elatine*, &c.

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Enneandria is a small class. The order *Monogynia* is remarkable as containing the fine genus *Laurus*, two species of which produce the Cinnamon and Camphor; *Anacardium*, the Cashew-nut. *Trigynia* contains *Rheum*, the Rhubarb; and *Hexagynia*, *Butomus*, the flowering Rush.

Decandria. The order *Monogynia* commences with a part of the large natural order *Leguminosæ*, plants with pea-formed flowers, and the seed-vessel a pod. Linnæus, with very slight violence to his system, might have retained the whole of the *Leguminosæ* in this class and order; and it is to be regretted that he did not, for certainly the separation has always been considered one of the greatest defects of his system. It is found that of the plants with pea-flowers, the seed-vessel a pod, and ten stamens, in some genera the stamens are free, in others they are united into two parcels. Strictly adhering to the rules of his system, he placed the former in this class and order, and the latter in the class *Diadelphia*; those here retained are elegant small trees and shrubs, among which are the genera *Sophora*, *Virgilia*, *Podalyria*, *Pultenea*, *Bauhinia*, the extensive genus *Cassia*, *Cæsalpina*, producing valuable dyewoods; *Hæmatoxylon*, the Logwood; *Toluifera*, the Balsam of Tolu, &c. To these succeed Jussieu's natural order *Rutaceæ*, containing *Guaiacum*, the Lignum Vitæ; *Zygophyllum*, *Fagonia*, *Ruta*, the Rue, &c.; *Crowea*, *Quassia*, so well known for its bitter qualities; *Limonia*, *Feronia*, *Gærtnera*; then follow some genera of the natural order *Meliaceæ*, as *Tremanthus*, *Trichilia*, *Swietenia*, the Mahogany, *Melia*, &c.; the interesting *Dionæa*, *Jussiæua*, *Dais*, *Ceratophyllum*, the beautiful and extensive genus *Melastoma*, *Meriana*; then some genera of the fine North-American *Rhodoraceæ*, as *Kalmia*, *Ledum*, *Rhodora*, *Rhododendron*, and some of the elegant *Ericaceæ*, as *Vaccinium*, the Cranberry; *Ceratostema*, *Andromeda*, *Arbutus*, Strawberry tree, &c.; *Erica*, the type of the order, being unfortunately left in the class *Octandria*, having only eight stamens.

*Digynia* is a small order, but contains several remarkable genera, among which are *Hydrangea*, *Chrysosplenium*, *Saxifraga*, an extensive alpine genus, and some of the natural order *Caryophylleæ*, as *Gypsophila*, *Saponaria*, and *Dianthus*.

The order *Trigynia* contains another portion of the *Caryophylleæ*, as *Cucubalus*, *Silene*, *Stellaria*, the Chickweed, &c., *Arenaria*, *Cherleria*, &c.; the natural order *Malpighiaceæ* follows; the genera are *Malpighia*, *Banisteria Hiræa*, *Triopteris*, *Tetrapteris*, and *Erythroxylon*.

*Tetragynia* has only one genus, *Micropetalon*.

*Pentagynia* commences with some genera of the natural order *Terebintaceæ*, as *Averrhoa*, *Tapira*, *Spondias*, *Pourpartia*, *Robergia*, and *Cnestris*; then follow some of the *Crassulaceæ*, as *Cotyledon*, *Sedum*, the Stonecrop, and *Penthorum*; the elegant and extensive genus *Oxalis*; another portion of the *Caryophylleæ*, *Agrostemma*, *Lychnis*, *Cerastium*, and *Spergula*.

*Decagynia* contains two genera, *Neurada* and *Phytolaca*.

In all the preceding classes the number of stamens is definite, but in the next class, Dodecandria, although the name denotes twelve stamens, they vary from eleven to nineteen; it is a small class.

In the order *Monogynia* are the genera *Asarum*, *Bocconia*, *Dodecas*, *Evodia*, *Bassia*, *Rhizophora*, *Brugiera*; several genera of the *Melastomeæ*, as *Blakea*, *Valdesia*, and *Axinæa*, *Decumaria*, *Cratæva*, *Triumfetta*; the elegant North-American *Hudsonia*, *Portulaca*, *Talmum*; several of the natural order *Salicariæ*, as *Crenæa*, *Pemphis*, and *Lythrum*.



*Digynia* contains only two genera, *Heliocarpus* and *Agrimonia*.

*Trigynia*, *Reseda*, Mignionette, *Aristolia*, the very extensive genus *Euphorbia* and *Visnea*.

*Tetragynia* has only one genus, *Calligonum*;

*Pentagynia*, *Glinus*, *Brunelia*, *Blackwellia*, and *Gastonia*; and

*Dodecagynia*, *Sempervivum*, the Houseleek.

Icosandria is a most important class. Here, as in *Dodecandria*, the number of stamens are not defined; they vary from about twenty to a hundred or more. It may readily be distinguished from the preceding or following classes by observing that the calyx consists of one concave leaf; that the petals are fixed by claws to the inside of the calyx; and that the stamens stand either upon the petals or the calyx, but not upon the receptacle: the whole class abounds in fine flowers and wholesome fruits.

The order *Monogynia* commences with the large Linnæan genus *Cactus*, several species of which are remarkable for their fine flowers, of which the night-blowing *Cereus* is a well-known example. The elegant natural order of *Myrtaceæ* follows: the principal genera are *Philadelphius*, *Leptospermum*, *Metrosideros*, *Melaleuca*, *Psidium*, *Eugenia*, *Caryophyllus*, the Clove tree, *Myrtus*, the Myrtle, *Calyptranthes*, *Eucalyptus*, a genus of fine trees, natives of New South Wales, &c.: the other genera of this order chiefly belong to the fine natural order *Rosaceæ*, which, with the *Pomaceæ*, as rich in fruits as the *Rosaceæ* in flowers, form the bulk of the class Icosandria. *Amygdalus*, the Peach and Almond, *Prunus*, the Plum, and *Cerasus*, the Cherry, are now separated into a distinct order called *Amygdaleæ*; and *Chrysobalanus*, Cocoa Plum of the West Indies, is the type of a new order called *Chrysobalaneæ*.

*Digynia* has only three genera, *Waldstenia*, *Cratægus*, White Thorn, and *Sorbus*.

*Trigynia* has but one genus, *Sesuvium*.

*Pentagynia* contains *Mespilus*, the Medlar; *Pyrus*, Apple, Pear, and Siberian Crab; *Cydonia*, the Quince; *Aronia*, the large South-African genus *Mesembryanthemum*, *Tetragonia*, *Aizoon*, and *Spiræa*, Meadow Sweet.

*Polygynia* commences with the universally admired genus *Rosa*, the Rose; which is followed by *Rubus*, the Raspberry, Blackberry, &c.; *Dalibarda*, a North-American genus allied to *Rubus*; *Fragraria*, the Strawberry and Hautboy; *Potentilla*, *Tormentilla*, *Geum* and *Dryas*, all elegant herbaceous plants; *Calycanthus*, the All-spice.

The class Polyandria may be readily distinguished from Icosandria by observing that the stamens are fixed to the receptacle; if, when the petals and calyx leaves are pulled off from a flower containing more than twenty free stamens, they remain fixed to the receptacle, it may be safely referred to this class.

In the order *Monogynia* are several important genera, as *Capparis*, the Caper Plant; those belonging to the natural order *Papaveraceæ*, all of which contain the narcotic principle called *morphia*. The most remarkable are *Papaver*, the Poppy; *Glaucium*, Horned Poppy; *Chelidonium*, the Celandine; *Sanguinaria*, &c.; *Sarracenia*, the American Pitcher Plant; *Nymphæa*, the Water Lily; the natural order *Tiliaceæ*, including *Tilia*,



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the Lime tree; *Sloanea*, *Grewia*, a large genus; *Corchorus*, *Lettsomia*, &c.; the natural order *Guttiferæ*, containing *Clusia*, *Stalagmitis*, the Gamboge Plant; *Mammea*, the Grateful Mammæ Apple, &c.; *Thea*, the Tea Plant: *Camellia*, *Citrus*, the Orange and Lemon; *Cistrus*, *Helianthemum*, &c.

*Digynia* is a small order, and contains no remarkable genus except *Pæonia*, the Peony.

In *Trigynia* are *Delphinium*, the Larkspur, and *Aconitum*, the Monkshood.

*Tetragynia* contains *Wintera*, with a bark containing an aromatic principle similar to Cinnamon, and *Caryocar*, the Butter-nut.

In *Pentagynia* are *Aquilegia*, the Columbine, *Nigella*, and *Reaumuria*.

The genera that compose the order *Polygynia* furnish some fine flowering plants, as *Nelumbo*, the splendid ornament of the rivers of the East; the noble natural order *Magnoliaceæ*, containing *Magnolia*, *Liriodendron*, the Tulip Tree; *Dillenia*, *Illicium*; the natural order *Annonaceæ*, *Annona*, the Costard Apple, *Uvaria*, *Gaulteria*, &c.; the elegant alpine genus *Anemone*, *Atragene*, the large genus of climbers, *Clematis*, *Thalictrum*, *Adonis*, *Ranunculus*, *Trollius*, *Helleborus*, *Caltha*, &c.

The class DIDYNAMIA contains those plants whose flowers are furnished with four stamens, arranged in pairs, one pair being always shorter than the other; they cannot be mistaken for those of the class *Tetrandria*, whose flowers have also four stamens, as in that class the stamens are not in pairs, and are always of a uniform length.

The orders in this and the following classes are not formed, as in the preceding classes, from the number of the styles, as in this and several others of the following classes the flowers have but one.

*Didynamia* is divided into two orders, *viz. Gymnospermia*, containing those plants that are not furnished with a proper seed-vessel, but have the seeds lying uncovered at the bottom of the persisting calyx, the number of seeds being usually four; the order *Angiospermia* contains those plants of the class whose seeds are contained in a proper seed-vessel.

The order *Gymnospermia* is, to a certain extent, a natural group, and contains most of the genera that form the order *Labiatæ* of the natural system; the plants of this order are remarkable for the aromatic, volatile oil, and a tonic bitter principle which they yield, on which account several of them are valuable in medicine, some useful for culinary purposes, and others for the production of essential aromatic perfumes: they are mostly natives of the Northern hemisphere. The most conspicuous genera are *Lavendula*, Lavender; *Mentha*, Mint; *Glechoma*, Ground Ivy; *Marrubium*, Horehound; *Hedeoma*, Penny-royal; *Thymus*, Thyme, &c. This order should have contained the whole of the *Labiatæ*; but unfortunately the strictness with which Linnæus arranged according to his system, obliged him to place several genera of the *Labiatæ* in the class *Diandria*, as *Salvia*, the Sage, which has only two stamens.

*Angiospermia* is a large order; in it we find *Aloysia*, generally cultivated on account of its fragrant lemon-scented leaves; *Gerardia*, *Chelone*, *Penstemon*, *Glorinia*, *Linaria*, *Antirrhinum*, the Snapdragon; *Schrophularia*, *Digitalis*, the Foxglove; *Bignonia*, the Trumpet Flower; *Crescentia*, the Calabash tree; *Browallia*, the elegant *Linnæa*, *Mimulus*, *Maurandia*, *Vitex*, a genus of fine Indian trees; *Acanthus*, *Melianthus*, the Honey-flower, &c.

The next class, TETRADYNAMIA, is the most natural of all the Linnæan classes, it being identical with the natural order *Cruciferæ*, whose essential character is "plants with hypogynous tetradynamous stamens."

All the plants of this class have the flowers furnished with six stamens, two of which are shorter than the other four, and therefore cannot be confounded with the plants in the class *Hexandria*, which have also six stamens, but all of a uniform length; another distinguishing character of *Tetradynamia* is, that all the flowers have four petals, which is not the case with Hexandrous plants.

The plants of this class are for the most part herbaceous, and are chiefly found in the Northern hemisphere: of more than eight hundred species described, about seven hundred are found in the Northern temperate and frigid zones, about thirty only belong to the tropics, and those in mountainous situations, as they cannot exist in a very elevated temperature; they abound in an acrid principle, which is much mitigated by cultivation.

The class is divided into two orders, depending on the form of the seed-vessel: *viz Siliculosa*, the pod being short, broad, and usually flat and round; and *Siliquosa*, the pod being long and narrow.

The order *Siliculosa* contains the genera *Cakile*, *Crambe*, the Sea Kale and Colewort; *Isatis*, Dyers' Woad; *Thlaspi*, Shepherd's Purse; *Iberis*, Condy Tuft; *Lepidium*, Pepperwort; *Linaria*, Honesty, &c.

The order *Siliquosa* produces some valuable esculent vegetables, as *Brassica*, the Turnip, and varieties of the Cabbage, *Raphanus*, the Radish, &c.; also *Cheiranthus*, the Wallflower; *Matthiola*, the Stock; *Nasturtium*, the Water-cress, &c.

The class MONADELPHIA consists of those plants that have the stamens united by their filaments into a tube through which the style passes.

This class is formed into nine orders, depending on the number of stamens; thus those with two stamens are in the order *Diandria*, three stamens the order *Triandria*, &c.: the class contains some very natural groups.

In the order *Diandria* are two genera, *Stylidium* and *Forstera*, composing the natural order *Stylideæ*.

*Triandria* contains *Tamarindus*, the Tamarind tree, belonging to the natural order *Leguminosæ*.

In the order *Pentandria* we find the extensive and elegant genus *Lobelia*, (placed by some Botanists in the class *Pentandria*,) *Hermannia*, *Melhania*, with wood resembling ebony; the large and beautiful genus *Passiflora*, the Passion Flower; *Erodium*, Crane's Bill; that immense South African genus *Pelargonium*, which furnishes the plants so much cultivated called Geraniums: in the flowers of this genus we find ten stamens, from three to six of which are without anthers; as this number is uncertain, some place the genus in the order *Heptandria*.

The order *Octandria* contains the genera *Pistia* and *Aitonia*.

*Decandria*, the genus *Geranium*.

*Endecandria*, the genus *Brownea*.

*Dodecandria*, the South-African genus *Monsonia*, *Helicteres*, the Screw tree of the West Indies, *Sterculea*, *Dombeya*, &c.

*Polyandria* is an important order. We here find *Adansonia*, the Baobab tree, considered to be the largest

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tree known, the diameter being sometimes thirty feet; *Bombax*, the Silk-cotton tree of the East Indies; but the most prominent feature of the order is the large natural order *Malvaceæ*, consisting of *Sida*, a large and beautiful genus; *Althæa*, The Marsh Mallow and Hollyhock; *Malva*, the Mallow; *Malope*, *Lavatera*, *Gossipium*, the Cotton tree; *Hibiscus*, &c.

The class Diadelphia includes those plants that have the stamens united into two sets of cylindrical filaments; and, although the class is in a great degree natural, it is, perhaps, the most faulty in the whole system, as it separates a very large group, comprising the order *Leguminosæ* of the natural system, into distant parts of the arrangement, one part being in this class, and part in the class *Decandria*. Many of the plants placed by Linnæus in this class can scarcely be called Diadelphous, as the stamens are all united at the base, with a slit down part of the tube scarcely separating one stamen from the others. Linnæus would have made his system a near approach to a natural arrangement had he adopted the plan of the modern constructors of natural orders, of including genera with some part of their character anomalous to the given character of the order.

The orders of the class *Diadelphia* are formed from the number of the stamens; they are four in number, *viz.*

*Pentandria*, five stamens; *Hexandria*, six stamens; *Octandria*, eight stamens; but the great mass of the class is contained in the order *Decandria*, ten stamens.

*Pentandria* contains but one genus, *Petalostemon*.

*Hexandria* three, *Saraca*, *Corydalis*, and *Fumaria*.

In *Octandria* are *Monima*, the large and elegant genus *Polygala*, *Comaspermum*, &c.

The order *Decandria* contains more than one hundred genera, among which are some that contribute largely to the necessities and comforts of man, as *Phaseolus*, the Kidney Bean; *Dipteria*, the fragrant Tonquin Bean; *Spartium*, the Broom; *Ulex*, the Furze; *Lupinus*, the Lupin; *Dolichos*, the Cowage; *Pisum*, the Pea; *Vicia*, the Vetch; *Ervum*, the Lentil; *Cytisus*, the Laburnum; *Glycyrrhiza*, the Licorice; *Indigofera*, the valuable Indigo; *Trifolium*, the Clover and Trefoil; *Medicago*, the Lucerne, &c.

The class Polyadelphia is one of the smallest and least important of the system, and has but little claim to be considered natural; it contains those plants that have the stamens united into three or more bundles.

The orders are founded on the number of stamens: they are *Decandria*, *Dodecandria*, *Icosandria*, and *Polyandria*.

*Decandria* contains only *Theobroma*, the tree that produces the nut of which chocolate is made.

*Dodecandria* has only two genera, *Bubroma* and *Abroma*.

In *Icosandria* are the beautiful New Holland genera *Melaleuca*, *Calothamnus*, and *Beaufortia*.

*Polyandria* contains *Symplocos*, *Xanthochymus*, the extensive genus *Hypericum*, several species of which are natives of England, the fructification affording good examples of the class and order, *Ascyrum*, &c.

The class Syngenesia is very large, and contains the plants that were arranged by preceding Botanists under the head of compound flowers. Syngenesious plants have a common calyx containing several florets, each floret having stamens and pistil of its own, or one of these organs, or neither. From this variation Linnæus formed six orders, *viz. Polygamia æqualis*, the florets containing both stamens and pistil; *Polygamia superflua*, the florets of the centre or disk of the flower containing stamens, whilst those of the circumference, or, as they are usually called, radial florets, have only a pistil; *Polygamia frustranea*, with the florets of the disk furnished with stamens and pistil, and the radial florets destitute of either; *Polygamia necessaria*, the florets of the disk possessing stamens only, the radial florets pistils only; *Polygamia segregata* is a modification of the first order; the florets are furnished with both stamens and pistil, but are separated from each other by means of a partial calyx which supports one or more florets, and are placed within a common calyx: this order contains no British genus. *Monogamia* contains only simple flowers, having their stamens united by their anthers: this order has been found to be so faulty and useless, that later Botanists have with common consent distributed the plants it contained into other classes.

The word *Polygamia* is usually omitted in describing a syngenesious plant; thus it is said to belong to the class *Syngenesia*, order *Æqualis*, &c.

The class *Syngenesia* is a natural group of plants, being the same as the order *Compositæ* of the natural arrangement, one of the characters of which is "syngenesious stamens;" that is, the stamens united into a tube by the coherence of their anthers, which is the identical character on which Linnæus founded the class.

The florets of a syngenesious plant are inserted into a receptacle, which organ is of importance in distinguishing the genera, it being in some genera surmounted by a chaffy covering; another character is the down with which the seeds are invested, of which the well-known seeds of the Dandelion, which float about in the summer, is a good example.

The most remarkable genera in the order *Æqualis* are *Tragopogon*, *Scorzonera*, *Sonchus*, *Lactuca*, one of the species of which is the Garden Lettuce; *Leontodon*, the Dandelion; *Hyoseris*, *Hieracium*; *Cichorium*, the Succory; *Carthamus*, the Safflower; *Arctium*, the Burdock; *Carduus*, the Thistle; *Cynara*, the Artichoke; *Eupatorium*, &c.

In the order *Superflua* are *Tanacetum*, the Tansy; *Artemisia*, the Wormwood; *Gnaphalium*, Everlasting Flower; *Xeranthemum*, *Elichrysum*, *Conyza*, *Erigeron*; *Tussilago*, the Colts-foot; *Senecio*, the Groundsel; *Aster*, a large genus, many species of which are cultivated; *Solidago*, the Golden Rod; *Cineraria*, a genus of fine flowering plants; *Inula*, the Elecampane; *Bellis*, the Daisy; that splendid ornament of our gardens, *Dahlia*; *Tagetes*, the French and African Marigold; *Zinnia*, *Chrysanthemum*; *Pyrethrum*, the Feverfew; *Anthemis*, the Chamomile, &c.

In the order *Frustranea* are *Helianthus*, the Sunflower and Jerusalem Artichoke; *Rudbeckia*, *Coreopsis*, *Gorteria*, *Gazania*; *Centaurea*, the Centaury, &c.

The order *Necessaria* contains *Calendula*, the common Marigold; *Othonna*, *Hippia*, *Filago*, *Micropus*, &c.

The order *Segregata* contains *Elephantopus*, *Echinops*, the Globe Thistle, *Rolandra*, *Gundelia*, &c.

The class Gynandria contains those plants whose flowers are furnished with a pillar-shaped receptacle resembling a style, which rises in the centre of the flower, and supports both the stamens and pistil.

Since this class was established by Linnæus several genera which he included in it have been removed to the other classes.

The orders are formed from the number of stamens in each.

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*Diandria* contains the large and interesting natural order *Orchideæ*, which has lately received considerable attention from Botanists and the cultivators of plants, on account of the introduction from various parts of the world of an almost inconceivable number of species, whose flowers, in beauty, variety, and singular formation, cannot be equalled by any other group of plants; several collections in this country contain from five to eight hundred species, and probably as many more are known. The introduction of many new ones may be anticipated, as it is found that they will live during a long voyage closely packed in glazed boxes from which the external air is excluded. They require no watering; all that is necessary is, that the roots be packed closely in moss, and the plants exposed to light. The *Orchideæ* in their structure are of importance to the vegetable physiologist; in no other assemblage of plants can be found such fine examples of the development of the organization of the tissue, stomata, spiral vessels, &c. Of those found in the warm climates, a large proportion are parasitic on the stems and branches of trees; of those indigenous to England, *Cypripedium calceolus*, the Lady's Slipper; *Ophrys apifera*, the Bee Orchis, and *O. muscifera*, the Fly Orchis, are examples.

*Triandria* contains but two genera, *Salacia* and *Rhapium*.

In *Hexandria* is the large genus of elegant climbing plants *Aristolochia*, and *Bragantia* native of Cochinchina.

The class MONOECIA differs essentially from all the preceding classes: here we find some of the flowers furnished with stamens only, and others with pistils only, but both on the same plant.

The orders are formed from the number, union, and situation of the stamens.

*Monandria* contains *Cynomorium*, *Ambrosinia*, then several genera of water plants, as *Zostera*, the Sea Wrack, *Zannichella*, and *Fluvialis*: *Chara* is now removed to *Cryptogamia*, *Ceratocarpus*, *Artocarpus*, the Bread Fruit, *Casuarina*, a genus of fine trees, *Elaterium*, &c.

*Diandria* is a small order, containing no remarkable genus except *Lemna*, the Duck-weed.

In *Triandria* are *Typha*, the Bullrush, and *Sparganum*, now forming the natural order *Typhaceæ*; then follow some genera of the grass tribe, *Zea*, the Maize; *Tripsacum*, *Coix*, the seeds of which are covered with a silicious coat, and are called Job's tears; several genera of the *Cyperaceæ*, as *Cobresia*, *Carex*, *Scleria*, &c.

*Tetrandria* contains several important genera, as *Alnus*, the Alder tree; *Buxus*, the Box tree; *Morus*, the Mulberry and Fustic; *Aucuba*, the extensive genus *Urtica*, the Nettle, &c.

*Pentandria* contains no remarkable genus except *Amaranthus*.

In *Hexandria* we find several of the Palm tribe, as *Cocos*, the Cocoa-nut, *Bactris*, *Elate*, and *Sagus*, the Sago Palm.

In the order *Polyandria* are placed all those Monoecious plants whose stamens are more than seven: among these we find *Ceratophyllum*, *Myriophyllum*, and *Sagittaria*, all water plants; *Begonia*, a genus of elegant shrubs, generally cultivated; *Ailanthus*, *Poterium*, the Burnet. But the prominent feature of the order is the group of valuable trees of the natural order *Amentaceæ* of Jussieu: as *Quercus*, the Oak, of which more than eighty species have been described; *Corylus*, the Hazel; *Fagus*, the Beech tree; *Castanea*, the Chestnut; *Betula*, the Birch; *Juglans*, the Walnut tree; *Carpinus*, the Hornbeam; *Platanus*, the Plane tree; *Salisburia*, the Maiden-hair tree; and *Liquidambar*, the Sweet Gum tree. The order also contains *Arum*, *Caladium*, and several genera of Palms, as *Manicaria*, *Caryota*, *Ceroxylon*, the celebrated Wax Palm described by Humboldt, *Iriarteæ*, and *Ladoria*.



The order *Monadelphia* contains those plants whose stamens are united. Here we find more Palms, as *Geonoma*, *Areca*, and *Nipa*; the large and important genus *Pinus*, the Pine, Cedar of Lebanon, and Fir tree; *Thuja*, the Arbor Vitæ; *Cupressus*, the Cypress; *Podocarpus*; several genera of the natural order *Euphorbiaceæ*, as *Plukenetia*, *Dalechampia*, *Acalypha*, *Croton*, *Iatropha*, *Ricinus*, the Palma Christi; *Hippomane*, *Hura*, the Sand Box tree, &c.; *Cytinus*, *Tricosanthes*, the Snake Gourd; *Momordica*, Balsam Apple; *Cucurbita*, the Bottle Gourd; *Cucumis*, the Cucumber and Melon; *Bryonia*, the Bryony; *Sicyos*, the Choco Vine, &c.

The order *Gynandria* contains only three genera, *Andrachne*, *Spermaxyrum*, and *Hyphydra*.

The class DIOECIA contains those plants whose flowers possess stamens only and pistils only on separate plants of the same species.

The orders are formed in the same manner as in the class Monoecia.

The order *Monandria* contains the noble genus *Pandanus*, the Screw Pine, *Brosimum*, *Ascarina*, &c.

In *Diandria* are the curious *Vallisneria*; the extensive genus *Salix*, the Willow; *Fraxinus*, the Ash; *Ceratolia*, &c.

In *Triandria*, *Empetrum*, *Stilago*, *Caturus*, *Osyris*, *Willdenovia*, *Restio*, *Calorophus*, *Ficus*, (removed here by some Botanists from the class *Polygamia*.) &c.

*Tetrandria* contains *Broussonetia*, *Olmedia*, *Anthospermum*, *Stilbe*, *Montinia*, *Viscum*, the Mistletoe; *Brucea*, *Hippophæ*, the Sea Buckthorn; *Myrica*, the Candleberry Myrtle, &c.

*Pentandria*, *Pistacia*, the Turpentine and Mastick tree; *Zanthoxylum*, *Securinega*, the Otaheite Myrtle; *Spinacia*, the Spinage; *Cannabis*, the Hemp; *Humulus*, the Hop Plant; *Ceratonia*, the Carob tree, &c.

In *Hexandria* are *Tamus*, the Black Bryony; *Smilax*, the Sarsaparilla root; *Rajania*, *Dioscorea*, the Yam; several Palms, as *Phœnix*, the Date Palm; *Elais*, *Chamædorea*, *Borassus*, *Hyphæne*, &c.

*Octandria* is a small order, but remarkable as containing *Populus*, the Poplar; *Diospyros*, the Ebony; *Rhodiola*, the Rose root, &c.

*Enneandria* contains only three genera, *Mercurialis*, the Mercury; *Hydrocharis*, the Frog bit; and *Hermesia*.

In *Decandria* are *Carica*, the Papaw tree; *Gymnocladus*, the Bonduc; *Kiggelaria*, *Schinus*, the Peruvian Mastick tree; and *Coriaria*.

In *Dodecandria*, *Stratiotes*, the Water Soldier; *Hyænanche*, *Euclea*, *Datisca*, and *Menispermum*.

In *Icosandria*, *Flacourtia*, *Gelonium*, *Rottlera*, *Hedycarya*, *Citrosma*, and *Peumus*.

In *Polyandria*, *Trewia*, *Embryopteris*, *Cliffortia*, *Cycas* and *Zamia*, remarkable plants, allied to the Palms, &c.

*Monadelphia* contains *Latania*, a genus of Palms; several of the natural order *Coniferæ*, as *Araucariæ*, the Norfolk Island Pine, probably the loftiest of trees, being at times two hundred feet in height; *Juniperinus*, the Juniper and Pencil Cedar; *Taxus*, the Yew;

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Botany. *Ephedra*, *Cissampelos*, &c., *Trichoa*, *Dryandra*, *Loureira*, *Myristica*, the Nutmeg tree, *Horsfeldia*, the remarkable *Nepenthes*, Ceylon Pitcher Plant, *Ruscus*, Butcher's Broom, *Xanthe*, &c.

The remaining order, *Gynandria*, contains only *Cluytia*.

The class POLYGAMIA, as established by Linnæus, included those plants some of whose flowers have stamens and pistils, and others stamens only or pistils only, either on the same plant, or distinct plants of the same species; but, in the classification of plants by several eminent Botanists since the time of Linnæus, the class has been abolished, and the genera which it contained distributed among the other classes, chiefly in *Monoecia* and *Dioecia;* thus we sometimes meet with the following in the description of the essential character of a genus in those classes, hermaphrodite flower, that is, the flower containing stamens and pistils, and male flower or female flower.

In the order *Monoecia*, containing those plants some of whose flowers are furnished with both stamens and pistils, and others with stamens only or pistils only, on *the same plant*, are the genera *Musa*, *Veratrum*, *Andropogon*, *Chloris*, *Holcus*, *Valantia*, *Parietaria*, *Atriplex*, *Rhagodia*, *Feronia*, *Clusia*, *Acer*, *Celtis*, *Inga*, *Mimosa*, *Acacia*, *Rhapis*, &c.

In the order *Dioecia*, containing those plants some of whose flowers are furnished with both stamens and pistils, and others with stamens only or pistils only, *on distinct plants*, are the genera *Fraxinus*, *Gleditschia*, *Brosimum*, *Diospyros*, *Hamiltonia*, *Laurophyllus*, *Arctopus*, *Panax*, *Ceratonia*, *Ficus*, *Chamærops*, &c.

At the end of these twenty-four classes Linnæus arranged the family of Palms in an appendix, and in this respect left his arrangement somewhat more natural than his successors, who have universally distributed the whole family among the preceding classes.

The last class, CRYPTOGAMIA, consisting of flowerless plants in which the organs of fructification are, from their smallness, or from their situation, entirely concealed or imperfectly visible, is as natural as could be desired; and the arrangement of Linnæus has been scarcely altered in any natural system of modern Botanists, they having only subdivided his four orders, *viz. Filices*, *Musci*, *Algæ*, and *Fungi*, and added the genus *Chara*, which he had placed in the class *Monandria*.

Linnæus, and the supporters of his system, having incontrovertibly established the doctrine of reproduction by distinct sexual organs in the plants of the preceding classes, vainly endeavoured to discover stamens and pistils in the class *Cryptogamia*. Great pains have been taken, and much has been written, to prove which were the male, and which the female organs in the different orders, although not bearing the slightest resemblance to stamens or pistils. The justly celebrated Hedwig's theory of the sexual organs of the Mosses has been generally supposed to be the true one, and has been adopted even by Botanists who do not consider that the sexual organs of Ferns have been discovered, and who even doubt their existence; but it is not likely that these organs should be lost in the Ferns, which are allowed to be nearly allied in organization to Phenogamous plants, and reappear in the Mosses.

The advantage of considering all the objects of Nature in two grand divisions only, namely, organic and inorganic, cannot too strongly be recommended to the Botanist. In comparing the physiology of animals and plants, he will meet with more analogies than he could expect, and which will very much contribute to guide him into the true path of discovery. Now no analogy can be more beautifully striking and correct than the similarity of the mode of reproduction of animals and vegetables; but those who have studied the physiology of the lower tribe of invertebrated animals are well aware that the mode of sexual reproduction becomes, in descending in the series, at first confused, (a confusion that commences in the *Insectæ*, as is well known to Entomologists, who have studied the reproduction of the *Aphides*,) and at length is lost altogether, in the *Animalcula infusoria*, and probably sooner: there is no trace of sexual organs, and their increase takes place from continued division of the individuals.

It may be urged that, although analogy would lead us to expect that, compared with the very lowest animals, the plants lowest in the scale of organization would be found to be destitute of these organs, yet that we might expect to find them in plants so high in the series as Ferns and Mosses; but is it not more philosophical to suppose, on a consideration of the superior order of the organization of animals in general compared with that of plants in general, that any function would cease earlier in the series of vegetables than animals?

Considering, then, the plants of the class *Cryptogamia* as destitute of sexual organs, the Linnæan system and the natural system is the same, and the classification of the plants it contains will be treated of under the latter head.

On reviewing the observations on the first twenty-three classes, it will be evident to an unprejudiced observer that it is more natural than could have been expected in any system professedly artificial; and if Linnæus had not been so strict to the character of his classes and orders, and, instead of forcing Nature to his system, had modified his system so as to have agreed more with Nature, it would have been very nearly as natural as could have been wished. In the most perfect of the natural arrangements that has hitherto been adopted, many of the orders contain anomalous genera that do not agree with all the characters of the order: thus one of the essential characters in the formation of an order is the number of cells in the ovarium. We find in many of the orders the character, ovarium many-celled; then we are told of some genera belonging to those orders with the ovarium only one-celled. If Linnæus had taken the same liberty with his system, it would not have been so deserving of the opprobrium to which it has been so deservedly subjected in consequence of the violent separation of large natural groups into different classes. Thus, in his class and order *Decandria*, *Monogynia*, if he had added the anomalous character of one stamen sometimes separated from the others, he could have brought all the papilionaceous *Leguminosæ* together which are now widely separated; and a similar remark will apply to almost every other natural group of plants that is divided in his arrangement. And it is to be regretted that this has not been done, for the sexual system would then have had the advantage over what is called the natural system in a most material requisite, that is, in presenting the whole vegetable creation in a linear, although artificial arrangement, affording facilities to the student for finding the situation of a genus which no natural arrangement possesses.

A very important defect in the Linnæan system, and

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which presents serious difficulties to the student, is the occasional inconstancy of the number of the parts of fructification, and even sometimes they are wanting; thus he will at times find only eight or five stamens in a plant belonging to the class *Decandria*: he will find also instances of plants with stamens only, or pistils only, which he will search for in vain in the class *Dioecia*, to which he would naturally refer. The uncertainty of the number of stamens is not so great as will at first appear, if the student makes it a rule to examine the terminal flower of any plant when considering to which class he should refer it, the terminal flower being usually perfect, and presenting the proper number of stamens required by the class. As to some species of a genus being Dioecious where the others possess both stamens and pistils, it is a defect of which, fortunately, there are but few examples. These anomalies, it should be remembered, cannot be urged against the Linnæan system only; all systems, however natural, are subject to them: thus, in the essential character of the natural order *Caryophyllæ* of the natural system, we find, "stamens twice as many as the petals;" yet a very common English plant of this order, the *Lichnis dioica*, is frequently found without stamens, although the usual number of petals are present.

### *Of the Natural System.*

Of all the systems of arrangement of organized beings the natural system must be the best; and of this truth, as regards plants, Linnæus was well aware, for he termed it "Nature's own method;" but he was also sensible of the difficulty of arranging the plants with which he was acquainted according to this method. This difficulty has in a great degree been overcome by the indefatigable labours of Jussieu, Decandolle, Brown, Lindley, and others, who have made great progress towards establishing a system of plants consisting of natural groups; but, unfortunately for the botanical student, an insurmountable obstacle presents itself in any attempt to arrange these groups according to their affinities in a consecutive series; indeed, such an arrangement is impossible, for every natural group consists of radiations from the species which may be considered the type of that group, that is, differing in character the most from any individual of any adjoining group, and consequently every group must be considered of a spherical character, and it will be found that it is allied to other groups at several points of its circumference; hence arises the impossibility of any natural linear arrangement, therefore every linear arrangement must be artificial. The compiler of a Dictionary could as easily form an arrangement of the words of a language in their true connections with the words to which they are allied, as could the Botanist form a consecutive series of genera or species of plants arranged according to their affinities.

The superiority of what is called the natural system over the artificial system of Linnæus will not be so apparent if it be granted, which it must be, that every natural system yet published, for the above-mentioned reason, must be to a certain extent artificial, and that the Linnæan system is to a certain extent natural, inasmuch as its principles depend on certain natural properties of plants. It is very probable that the most convenient mode of studying the natural groups of orders and genera would be to adopt the Linnæan arrangement as an index, especially if modified so as to allow the scattered fragments of natural groups to be collected into those classes and orders which already possess the genera in which the typical character of the group that has been broken is the most perfect.

The foundation of the natural system, on which succeeding Botanists have erected their several superstructures, was laid by M. A. L. de Jussieu, in 1789. The publication of his justly celebrated *Genera Plantarum secundum Ordines Naturales disposita* will always be considered an important event in the annals of botanical science; the following is his arrangement:

| | | | | | Class |
|---|---|---|---|---|---|
| Acotyledones. | | | | | 1 |
| Monocotyledones. | | Stamina | hypogyna | | 2 |
| | | | perigyna | | 3 |
| | | | epigyna | | 4 |
| Dicotyledones | Apetalæ | Stamina | epigyna | | 5 |
| | | | perigyna | | 6 |
| | | | hypogyna | | 7 |
| | Monopetalæ | Corolla | hypogyna | | 8 |
| | | | perigyna | | 9 |
| | | | epigyna | Antheris connatis | 10 |
| | | | | Antheris distinctis | 11 |
| | Polypetalæ | Stamina | epigyna | | 12 |
| | | | hypogyna | | 13 |
| | | | perigyna | | 14 |
| | Diclines irregulares | | | | 15 |

These classes he subdivided into a hundred orders, commencing with the *Fungi*, and finishing with the *Coniferæ*. His successors, although they have generally adopted his orders, have not followed his arrangement, but have placed the plants of the most simple organization last; which is to be regretted, as being contrary to the method that has been adopted by the best comparative anatomists, of commencing with the simplest organization, and tracing the developement of organs in an ascending series. The simplest form is probably the most eligible point both for the physiologist and the systematic Botanist to commence their investigations of the anatomy and affinities of plants.

Jussieu left his arrangement unfinished, for at the end of his orders he gives an appendix of one hundred and thirty-seven genera of *Plantæ incertæ sedis*; but now no genus is allowed to be of uncertain situation, for if it is found to belong to no order already adopted it is made to consist of an order by itself.

In the natural system two grand divisions are now universally adopted, namely, vascular or flowering plants, and cellular or flowerless plants; the former

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division containing those comprised in Linnæus's twenty-three first classes, and the latter those of his twenty-fourth class, *Cryptogamia*.

The arrangement followed by De Candolle does not differ in any essential point from that of Jussieu. He begins, it is true, with *Dicotyledones*, and ends with *Acotyledones*; therefore only reversing the orders of Jussieu. He divides the *Dicotyledones* or *Exogenes* into four subclasses, *viz*. 1. *Thalamifloræ*; petals many, distinct, inserted with the stamens into the receptacle, corresponding to the fourteenth class of Jussieu: 2. *Calyciflora*; petals many, distinct or united together at the base, and, like the stamens, are inserted into the calyx, agreeing with the ninth, tenth, eleventh, twelfth, and thirteenth classes of Jussieu: 3. *Corollifloræ*; petals united into a monopetalous corolla which bear the stamens; this corresponds to the eighth class of Jussieu: 4. *Monochlamydeæ*; corolla wanting or united with the calyx, corresponding to the fifth, sixth, seventh, and fifteenth classes of Jussieu. His second class, *Monocotyledones* or *Endogenes*, agrees with the second, third, and fourth classes of Jussieu; and his third class, *Cellulares* or *Cryptogamia*, with the first class of Jussieu.

In order that the natural classification may be sufficiently understood, it will be necessary to give a proper idea of both the elementary and compound organs of plants, and the general objects of that classification.

## PART I.—ORGANOGRAPHY, OR THE STRUCTURE OF THE PARTS OF WHICH VEGETABLES ARE COMPOSED.

### A. *Of Elementary Organs of Plants.*

The different parts of which a plant is composed have been termed its organs, and these have been again divided into elementary and compound organs; the former comprise the tissue, and the latter those larger combinations of elementary parts which are destined to the performance of the vital functions. Elementary organs are made up of minute vesicles and cavities, and various cylindrical tubes of a form much more lengthened. These organs, combined together under a variety of forms, are the bases or element of all vegetable bodies. A plant may be said to consist of solid and fluid parts; the fluid parts are the sap or juices, and the solid parts are the reservoirs in which these are contained, and are either cellular, spiral vessels, ducts, or tubes; but in respect to their external form, they resolve themselves into cellulac vessels or cavities. The first elements of vegetable organization are considered by Turpin, Meyen, and others, to be those minute globules which are contained in the fluids of plants; and they regard membrane and fibre as the secondary forms, originating in the subsequent melting of the globules. The vegetable membrane is a thin, elastic, transparent, homogeneous pellicle; and fibre is a fine, strong, elastic thread, which is usually of a silvery colour. It is solid, more or less compressed, but is sometimes also cylindrical or quadrangular. The inorganic elements composing vegetable membrane and fibre are oxygen, hydrogen, and carbon; the two first are the elements of water, and the othec occurring in various springs in the earth, in various combinations, and in the atmosphere in the form of carbonic acid gas. The elementary organs of plants are generally divided into four systems or classes, namely, cellular tissue, spiral vessels, ducts oc tubes, and woody fibre; bot these different tissues are so nearly allied in structure, that in many instances they pass by insensible gradations from one form to another. Cellular tissue, which constitutes the largest part of the vegetable body, consists of an assemblage of cellules placed in juxtaposition, each forming a closed vesicle endowed with an independent existence, having no communication by means of pores with the surrounding tissue; it abounds in phænogamous plants, and forms the entire mass of most cryptogamous plants. Cellules are said to be regular when they approach a mathematical figure, and when this is not the case they are said to be irregular. Meyen has arranged cellular tissue under two heads, namely, regular and irregular, the varieties of which are as follows: 1. *Merenchyma*, consisting of spherical cellules which partly touch each other; 2. *Parenchyma*, cellules arranged end to end, that is, with their flattened bases towards each other; 3. *Prosenchyma*, cellules overlaying each other at their ends; 4. *Pleurenchyma*, cellules which are long and united by their side walls. Cellules with markings of fibre are distinguished from the preceding class by the presence of markings or fibre, analogous to and apparently of the same nature as those occurring in dotted and annular vessels, or they resemble spiral vessels in having one or more spiral fibres generated within them, and in their capacity to unrol. Meyen is of opinion that the increase of cellular tissue takes place from the deliquescence of the globules. It is certain that in the genera *Chara* and *Nitella* globules are seen enclosed one within another. Vascular tissue is a general term for lengthened vessels, and has been applied to all those organs analogous to cellules, but of a much more lengthened form, whose extremities extend beyond the limited field of the microscope. They abound in the higher classes of plants, which have thence been denominated *Vasculares*, but are altogether wanting in the *Cellulares*, although they occuc in the family of *Lycopodiaceæ* and *Equisetaceæ*, included by most botanists in the *Cellulares*. They constitute, however, even in the highest orders of vegetables, a much less considerable part of the structure than cellular tissue. Authors recognise a great variety of vessels, and have given to each a different name; but they are clearly all referrible to one type, namely, the spiral vessels, of which they are modifications. Vascular tissue differs in no respect from cellular tissue except by its more elongated form; it consists of membranous tubes, with conical closed terminations extending beyond the field of the microscope, and furnished with markings or fibre. The mutual gradations of similarity of structure between the two kinds of tissue will scarcely admit of ascribing to them separate functions in the vegetable economy. Spiral vessels constitute the highest form of vegetable tissue; they occur in abundance in the primary classes of phænogamous plants, and more sparingly in the higher orders of cryptogamous plants; they are the longest of all vessels; they enclose one or more spiral fibres, which adhere to their walls; and they differ from other vessels in their greater capacity to unrol, as has already been stated, and are always simple, continuous tubes. Annular vessels are regarded by Meyen as the first degree of metamorphoses of the spiral vessels; in them the fibre is separated into distinct rings, or is partially spiral; they occur in all parts of vascular plants, but especially in those parts subject to elongation. Ducts or tubes are evidently of the same nature as spiral vessels, differing from them in their usually



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Botany.

larger size, and in their rarely possessing the capacity to unrol; they consist, like spiral vessels, of a membranous tube, with conical closed terminations, and are marked with bars and dots arranged more or less in a spiral manner. Reticulated vessels resemble annular vessels, but they are of larger dimensions, and are furnished with transverse bars, which are more or less complete, and sometimes form the entire circle of the tube, as in annular vessels, and occasionally assuming in some parts the appearance of the spiral vessels, and in others a dotted character. The transverse bars of these vessels are connected together by intermediate ones. Dotted vessels or ducts resemble the last in size and form, only differing in having their walls marked with dots, usually of an oblong form, and frequently exhibiting a spiral arrangement; these dots, like the spiral fibre, adhere to the walls of the tube and not to the outside. Simple ducts are simple, membranous, transparent tubes, without either dots or lines, and resemble the tubes of the woody fibre, of which they are probably nothing but a variety distinguished by their larger dimension; they occur in Asparagus, and some other herbaceous plants. Woody fibre consists of elongated cellules, most frequently fusiform, and terminating conically at both ends; they are, however, sometimes rounded or abrupt at the extremity, and often terminate obliquely: these tubes vary in diameter and length. The following varieties of woody fibre have been observed: 1. simple, transparent tubes, which is the most common form; they are large, and of a thinner texture in Asparagus: 2. tubes having minute, round dots, apparently disposed irregularly, as in *Calycanthus:* 3. tubes furnished with circular disks, with a more prominent and opaque centre, a circumstance which, however, arises from the manner in which the light is refracted through them; they appear to be external, and are possibly glands destined for a peculiar secretion; they are arranged in one, two, or three lines parallel to the medullary rays in *Coniferæ;* these disks appear to consist of two circles, one within another, and in the genus *Araucaria* the outer circle is hexagonal: 4. tubes having a spiral fibre developed within them, as in *Pinus Douglasii* and *Taxus baccata*. The woody fibre of *Pinus Douglasii* consists almost entirely of this variety, which occurs also in *Cycadeæ*. The membrane of woody fibre is much stronger than that of spiral vessels, and the thickness in general is nearly equal to that of the diameter of the vessel itself.

Besides the above there are also spurious organs arising from the arrangement of the tissue; the first of these are called intercellular passages, and under this head may be included the interstices of the cells, reservoirs of the proper juices, air cavities, and those canals containing the coloured fluids of plants: the first are almost always full of sap. The canals of coloured fluids are regarded by Schultz and Meyen as a form of vessels endued with a distinct enclosing membrane, but they are evidently nothing more than prolonged and ramified intercellular passages, analogous to air cavities, but containing coloured fluids instead of air: these canals have only been observed in milky plants, as in *Papaveraceæ*, *Euphorbiaceæ*, *Artocarpeæ*, &c. Some physiologists have been disposed to regard these coloured juices in plants as analogous to the blood in animals.

Plants secrete in their tissues juices of different kinds; commonly coloured or odoriferous, which, distending, burst the sides of the cellules so as to form small reservoirs of what are called the proper juices; these cavities were considered by the older botanists as proper vessels, but they have since been proved to be open reservoirs in the cellular tissue. The following forms of these reservoirs have been recognised: 1. the vesicular reservoirs; these present the appearance of rounded or oblong vesicles in the leaves of many plants, and are found to contain volatile and aromatic oils; they are very visible in *Aurantiaceæ*, *Myrtaceæ*, *Hypericineæ*, &c., under the form of pellucid dots, and in *Samydeæ* and *Myroxylon* in the form of pellucid lines: 2. the cæciform reservoirs; these are short tubes, usually obtuse at the ends; they are the reservoirs of volatile oil, found in the fruit of *Umbelliferæ*, and there termed vittæ: 3. the tubular reservoirs are tubes of an indeterminate length, and occur in the tissue of *Coniferæ* and *Terebinthaceæ:* 4. the fascicular reservoirs are bundles of small parallel tubes, met with in *Apocyneæ*, the bark of hemp; 5. the accidental reservoirs, so called by De Candolle because they vary in their form as well as position; they occur in the pith of certain *Euphorbiaceæ*, and in the tissue of *Coniferæ*. In the cells of many plants are found cavities of various dimensions filled with air, and are hence called air cavities, and which are often apparent without the aid of the microscope, and they are particularly large in stems and petals of aquatic plants; they originate from the disunion of the elementary organs, produced by the rapid developement of certain parts of the plant, or by a greater or less want of adhesion prevailing between portions of the cellular tissue. The hollow stems of *Gramineæ* and other plants may be regarded as a most extensive form of cavities of this description, the rapid growth of the stems occasioning an entire rupture of interior cellular tissue or pith. The vesicular bodies attached to *Utricularia* are cavities of this description, which botanists contend serve to float the plant during the period of flowering. The petioles of *Pontederia azurea* and some other plants are filled with these air cavities.

*On the separation and connection of the parts composing the vegetable tissue.*—The solidity of the vegetable tissue does not only depend on the nature of its component parts in each plant or organ, but on the manner in which these parts are arranged. Nature, however, never neglects the precaution of placing them in such a manner as to give the greatest strength and solidity to the structure. At the base of the leaves and of other organs, the cellular vessels are always by some unknown cause placed end to end instead of being mutually pressed together as in other parts, and consequently the weight of the organ, combined with chemical alteration of the vegetable tissue, produces a rupture at the point of articulation. The separation is sometimes the mere disunion of the two membranes; sometimes it is a rupture of certain parts; the withdrawing of the vital action produced by desiccation, and the unequal adhesion of various elementary organs, are the determining causes of these phenomena.

### B. *Of Compound Organs of Phænogamous Plants.*

*Of the cuticle or epidermis and its appendages.*—The cuticle is the outer membrane of leaves and young stems, &c., is readily detached, and is composed of cellular tissue. It bears the hairs, the apertures called stomata, lenticels, and prickles. That which distin-

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guishes the cuticle from any other superficial membrane is the existence of small oval chinks or holes called stomata. These stomata are rarely to be seen without the assistance of a microscope; they are situated between the ordinary cellules which compose the cuticle, and principally upon the parenchyma of the leaves between the nerves; they are usually situated on the under surface, but sometimes on both. In some monocotyledonous plants, as in *Iris*, they are arranged in straight lines; in *Begonia*, *Crassula*, *Saxifraga* they are disposed in rosettes, that is, they are accumulated in little circles, but evidently separate. The edges of stomata are composed of two cellules each, which appear to be thinner than those which compose the cuticle. They are less sunk in the cuticle, and produce by their form and their degree of tension orifices of different dimensions. The openings of the stomata correspond to the air cavities; it has been often remarked that the more stomata the more readily the cuticle separates. They are said to be wanting in *Cuscuta*, *Monotropa*, *Potamogeton*, *Myriophyllum*, and several other vascular plants; but the parts of aquatic plants which are exposed to the sun even by accident are furnished with stomata. In *Nymphæa*, the upper surface of the leaves are furnished with stomata, while they are absent on the lower surface. In *Algæ Lichenes*, *Fungi* they are said to be absent; they have, however, been discovered on the theca of some mosses. Lenticels are the small spots or dots which are found on the surface of the branches, and in some herbaceous stems of dicotyledonous plants. The lenticels are usually of a paler colour than the cuticle; they render the surface of branches more or less rough; their centre is flat or depressed, their form is usually oval; they augment in size as the branch increases in thickness. They disappear with the cuticle like the stomata, of which their origin is supposed to have some analogy. Lenticels are of vast importance, as they throw out the young roots when a slip or branch is put into the earth or water. The surface of the cellular tissue often produces appendages formed of lengthened cellules, which are called hairs, villi, prickles, &c. They are situated upon the outer surfaces of vegetables, as on the nerves of leaves and on young branches. Their form is variable, the following are the most usual: 1. simple hairs are composed of one cellule: 2. articulated hairs formed of many cellules placed one above another: 3. branched hairs composed of many cellules, which diverge in different directions; as forked, trifurcate, and stellate hairs, according to the number of the cellules; these hairs either separate or divide at the base, or may be combined at the base, as in *Elæagnus*: 4. bristles or prickles are composed of many cellules united together by their length, so as to form a cone: 5. seta or bristles are stiff and simple hairs: 6. scarious hairs are stiff, dry, and enlarged into scales, as in the stipes of Ferns, calyxes of *Compositæ*, &c.: 7. lymphatic hairs are those in which no liquid runs out, and are not fixed to any gland: 8. glandular hairs are those which are furnished with glands at their extremities; they are called glanduliferous when they support a small gland: 9. capitated hairs are those which are terminated by a swelled spherical gland, as those of *Fraxinella*: 10. polycephalous hairs are branched hairs, every branch being terminated by a gland, as in some species of Croton: 11. Excretory hairs are those which are seated on glands and serve for canals to the juices of these glands which are always caustic, as in some species of *Malpighia*.



*Of the stem.*—The parts which compose vegetables are necessary to the life of every plant, and are therefore called fundamental organs, or organs of nutrition; they are readily distinguished in phænogamous plants, and are known under the names of stem, root, and leaves. Among cryptogamous plants it is difficult to establish any distinction. The two fundamental organs, branches and leaves, are modified so as to produce germs or new plants, and in this modified state they are called organs of reproduction. In this manner the organs of nutrition serve to maintain the life of the individual, and that of reproduction the life of the species; these last are derived from the first, and both are composed of the elementary organs. The stem in phænogamous vegetables is that part between the root and the leaves; that point of a stem which unites to the root is called a collum or neck. Stems are either herbaceous or woody, simple or branched; when branched, it is generally distinguished by the names trunk and branches. In some plants there is no evident stem, and the leaves seem to rise directly from the root; in this case the plant is said to be stemless, or without a stem. When the stem is very short, and is hidden in the earth like a root, it is called a rhizoma, as in *Arum*, *Nymphæa*, *Iris*. In many plants the stem is naturally buried in the earth, as in *Salix herbacea*, &c. In the Onion, Tulip, Hyacinth, &c. the stem is the centre of a multitude of leaves in the form of scales, which constitute the greater part of the Onion, &c. The central body which bears the root and scales commences by being frequently globular and flattened beneath; sometimes these underground stems are swollen into irregular tubercles, as the Potato, and sometimes they are swollen out at their centre into a single tubercle, as in Cyclamen. All these have a tendency to rise vertically at first; therefore they are generally erect or ascending, that is inclined at the base, but erect the greater part of their length. When stems lie upon the ground they are said to be prostrate, and in this position, if they throw out roots from the axils of the leaves, they are then said to be creeping. If stems lean or fix themselves to any support, they are called scandent, and in this position, if they twist round that support in a spiral manner, they are said to be twining. It is remarkable that these stems twine from the right to the left, and from the left to the right, in a mode which is constant in every species. If branches rise directly from the axil of a leaf, they are said to be axillary; more rarely they are situated under, at the side, or opposite the leaves, they are then said to be extra-axillary, opposite the leaves, &c. The spaces from leaf to leaf are called the internodes, and must not be confounded with articulations; the Vine, Geranium, and Balsam are good examples of the latter. The stem of a grass is called the culm; stems are said to be radicant when they throw out roots at a distance from the earth, as Ivy, *Bignonia radicans*, and Mangroves. The Strawberry emits from the axils of the lower leaves cylindrical stems called flagellæ, which throw out roots at their extremities as well as leaves, and form new plants which can live independent of their parent. The stems of exogenes or dicotyledonous plants are composed of pith, wood, bark, medullary rays, and medullary sheath. In the centre of all exogenous stems are found cylindrical or prismatic canals filled with cellular tissue, which is the pith; the cellules which compose it

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are whiter than other cells, but are truly homogeneous. The cellular tissue which constitutes the pith is surrounded by a case formed of fibres, which are called the medullary fibres; some plants, instead of having these fibres ranged in an outer circle, have them scattered through the pith, as in some *Umbelliferæ*; tubes or vessels have been observed in the pith of others. Independent of these fibres there is a ligneous sheath which immediately surrounds the pith, and is called the medullary sheath. In most exogenous stems the woody fibre is placed in concave layers from the pith outwards; these layers are distinctly seen in a transverse section of Pinus, Oak, or other trees. A layer is produced in each year, so that the age of a tree may be known by the number of layers or reys in the transverse section. There are plates of cellular tissue in wood directed from the centre to the circumference, and these are called the medullary rays; in a horizontal section of wood these plates or rays appear like the lines on a sun-dial. They are composed of one or two layers or beds of flattened, ovoid, or four-sided cellules placed end to end. In exogenous plants the stem increases by external layers having the bark distinct; but in the endogenous plants the stem increases by internal layers having no distinct bark. The stems of the ligneous species of these last are composed of fibres, which approach more towards the circumference of the trunk than in the centre, and therefore the layers of wood or bark cannot be distinguished as in exogenous stems. The leaves embrace the stem and have their bases persistent, and form a kind of envelope, under which a thin layer of cellular tissue is to be found; at length the bases of the leaves fall off, leaving the layer of cellular tissue outside, which is analogous to the young bark of *Exogenes*; it is green outside and separates readily from the wood, and is pierced by small holes which are arranged regularly, and are the points by which the fibres communicate from the leaves to the centre of the trunk, as in Yucca and Palm trees. The buds in these are developed at the extremities of the stems or branches. The fibres are composed of five different kinds: cellules, long solid cellules, long tubular cellules, large dotted vessels, many-sided long cellules, and ducts. The parts of the stem of an exogene is hardest towards the circumference.

*Of the root.*—The root or descending axis is the lower part of a plant by which it fixes itself to the soil, and through which the liquids pass which serve for its nutrition. The root is opposed to the stem for it lengthens downwards and the stem upwards, and the branches of both root and stem are opposed in the same manner. Roots are without pith in the centre, and without stomata on the surface, and bear no appendages analogous to leaves. A root is visible in the seed, and is then called a radicle, and this is often furnished with lymphatic hairs which aid it in fixing the plant in the soil, and which probably absorb water, but they disappear altogether after a short time. The extremities or tips of roots which absorb water in the manner of a sponge have hence been denaminated spongioles; their organization is complicated; the interior is composed of cellular tissue, but this tissue lengthens out, and is in consequence always new or young; it is not covered by that layer of old and hardened cellules which forms the epidermis in all the rest of the plant, and it is consequently conceived that they have a high degree of that innate property of all vegetable tissue to absorb moisture. Roots which are exposed to the air, as those of *Pandanus*, or in water, usually present at their extremities a kind of hood, which appears to be the remains of an epidermis, torn probably by the elongation of the root. The composition of a root is more simple than that of a stem, and varies less in the different classes of vascular vegetables; it is composed of bark, wood, and medullary rays, the two first parts are composed of layers; the bark is often very thick, and is altogether composed of cellules. Roots have a disposition to form branches as the branches have roots, particularly where the roots are long and creeping, as in some *Acacias*, *Rhus*, *Ailantus*, &c. The varieties of form in roots is as follows: a simple root is that which has a single base in continuation of the stem, and a multiple root is that which divides at the neck: this last is frequent in monocotyledonous plants, but they are probably the lateral remifications of an old root which has been destroyed, or adventive roots of the lower part of the stem, as is seen in the Onion, Liliaceæ, Palms, &c. Simple roots, which descend perpendicularly, are called the axis; when they are swollen like Carrots they are termed fusiform; and when they are still more swollen at their origin, as the Radish, they are said to be rapiform; if they are round, and not particular in form, but variable, they are called tuberous. When the principal root is in part destroyed, it is said to be præmorse, and the lateral ramifications are called fibrillæ or small fibres. When these fibres are numerous, and the principal root destroyed or not distinguishable, the root is then said to be fibrous or branched. When the fibres are disposed in bundles, as the immersed root of Willow in water, it is called haired. Sometimes there are swellings along the fibres, the root is then called nodulose or knotted. Finally, when the ramifications spread near the surface of the earth, roots are termed creeping, &c. The multiple roots offer the same modifications as simple roots; as for instance in Dahlia, there are numbers of fusiform roots in a bundle; this kind of root is called fascicled or fasciculate. In Orchis two of the roots are swollen out into tubercles, varying in form in different species, while the other roots are cylindrical; these may be either branched or nodulose, as in simple roots. The different swellings or tubercles of roots are always filled with amylaceous matter, which serves as nourishment to the plant. Underground stems have often a great resemblance to roots, as for instance the Potato, Cyclamen, Couch Grass, &c.

*Of the leaf, its form, situation, and arrangement.*—Leaves are the lateral appendages of branches, and sometimes of stems or the lungs of vegetables, which, brought in contact with the air, undergo important modifications; they are composed of fibre and cellular tissue; the fibres of the leaves generally contain more vessels than that of the branches, of which, however, they are only a continuation; the cellular tissue contains much colouring matter, the ducts and spiral vessels issue in bundles from the branch before they pass into the lamina, and this contracted part is denominated petiole or leaf-stalk by botanists; and the flat part of the leaf which is supported by the petiole is called the limb or lamina; but if the bundles of fibres or vascular tissue diverge directly on issuing from the branch, the leaf is termed sessile, that is, destitute of a petiole or contracted part. The limb is composed of nerves more or less ramified, and parenchyma, which is the cellular substance between the nerves; the nerves are called primary, secondary, or tertiary, and so forth, according

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to the number of times they branch, but sometimes these nerves are divided to extreme tenuity; they are then denominated veins. The flat leaf has a superior and inferior surface, and the mesophylle, which is the substance between the two surfaces, and is in more or less abundance, consequently the consistence of leaves is variable; both surfaces of the leaf are covered with a cuticle, often furnished with hairs upon the nerves, and of stomata upon the parenchyma. The inferior surface is commonly paler than the upper, and furnished with more hairs on the nerves, more stomata on the parenchyma, and more air cavities, and having the cuticle more distinct. The leaves of aquatic plants that float upon the surface of the water are without stomata on the under surface; the leaves of some plants, particularly of the family of *Proteaceæ*, have a similar number of stomata on both surfaces, which causes either side to be greyish, at least of a uniform colour, and gives to the forests of Australia, where the plants of that family are very common, a sombre and monotonous appearance. The greater part of the leaves of trees have the stomata on the under surface, but in *Protea* and others, where by the twisting of the petiole both surfaces are presented obliquely to the horizon, stomata are to be found equally distributed on both surfaces. The petioles in all dicotyledonous plants are articulated at the base, and fall off at that articulation, the leaves are then called deciduous, but when the limb is fixed round the stem or branch it is persistent; this is the case in most monocotyledonous plants: a leaf is said to be simple when all its parts adhere together, and compound when certain parts called leaflets are articulated upon the petiole. According to the number of stomata on the surfaces of leaves, they become readily dried or moistened; for in succulent plants there are much fewer stomata in a given space than on the leaves of other plants, the moisture in them, therefore, does not so quickly evaporate.

*The petiole* in the greater number of leaves can readily be distinguished from the limb; it is ordinarily cylindrical or channelled on the upper side, or compressed laterally as in Poplars, which circumstance causes the great mobility in the leaves of the Aspen; petioles may be marginate, that is, having the lateral portion foliaceous and analogous to the limb: *Lathyrus aphaca* and *Dionæa* are good examples of the latter. This dilated portion of the petiole is sometimes rolled back on both sides, and is joined into a vessel, as in *Nepenthes* and *Sarracenia*, in which the operculum or lid is the true limb, and the pitcher or mug is the petiole which is generally filled with water. The vaginæ or sheaths in grasses and other allied families are analogous to petioles in which the fibres are parallel. The petiole may be sheathed or stem-clasping towards the base, as in the families *Ranunculaceæ* and *Umbelliferæ*. A sheathing petiole may want the limb, as in *Bupleurum perfoliatum*, and other umbelliferous plants; and in *Lepidium perfoliatum*, where at the base of the plant the petioles are furnished with a limb, but in those towards the top of the branches the limb entirely disappears. The petiole when broad and leaf-like, and without any limb, as in many species of Acacia, is called a phyllodium, and is readily distinguished from a true leaf by the nerves or fibres being parallel, and by its vertical position, which in a true leaf is horizontal; in the interval between the fibres are found stomata. In the seedling state of Acacia, however, the leaves are always present. Even where the limb is not developed, the petioles are sometimes cylindrical as ordinary, and give the plant the appearance of a rush, as in *Indigofera juncea*, *Viminaria denudata*, *Strelitzia juncea*. Often in compound leaves the petiole is terminated by a spine, as in *Astragalus adragans*, or tendril, as in *Vicia*, *Lathyrus*. In *Lathyrus aphaca*, however, leaves are wanting altogether, although the petiole is terminated by a tendril.

*Of the direction and arrangement of the vascular tissue or nerves in the limb.*—The nerves have already been mentioned as primary, secondary, &c.; but they are the most important parts of the limb, and determine the general form of the leaf. In dicotyledonous plants the primary nerve or nerves diverge in a right line from the base of the limb, and the different subdivisions of these nerves separate also in a right line from their origin; these are called angulinerved. In monocotyledonous plants the nerves form a curve at the base, and these are termed curvinerved. In the first there are four distinct dispositions of the primary nerves, (ribs or midribs.) 1. In a feather-nerved leaf, in which there is only one primary nerve or midrib, the secondary nerves spreading from it similar to the feathers of a quill, that is pinnate, in which case the leaf is more or less elongated, oval, elliptic, orbicular, obovate, &c., and is the most common form of nervation. When the two lower secondary nerves are stronger than the rest and as thick as the midrib, the leaf is called triplenerved; but when four of these secondary nerves resemble the midrib, the leaf is termed quintuplenerved, which is the case in many melastomaceous plants; the latter form runs into the following. 2. In a palminerved leaf the primary nerves are numerous, and rise from the base of the limb like the fingers of the hand or the divisions of a fan, the central nerve being the prolongation of the petiole; each of the lateral nerves are secondary nerves, as in the feather-nerved leaf. M. De Candolle justly remarks that palminerved leaves are only found in plants belonging to families whose leaves are compound, and may be considered as composed of as many leaflets as there are primary nerves. 3. In peltinerved leaves the nerves proceed from the petiole in a radiating manner, a good example of which is found in the leaves of *Nasturtium* or *Tropæolum*, in which the limb is round or roundish, and the petiole more or less in the centre of the limb. 4. In pedalinerved leaves the central nerve is very short, and even sometimes almost wanting, while the two lateral nerves are well developed, and bear secondary nerves which are very feeble on the outer, and very strong on the inner side of the leaf; the *Helleborus fœtidus* and some Arums are good examples of this form, but the latter tend to the curvinerves. In monocotyledonous plants, where the leaves are curvinerved, there are generally a great number of nerves separating from the base, where they form curved lines which are usually less prominent than in the preceding leaves; this kind of nervation is characterised by the dilated petioles. In most cases the nerves unite or converge at the tops of the leaves, as in *Iris* and *Hemerocallis*; in this case the nerves nearest the centre are straight, and the others curved, for it can hardly be said there is any central nerve or midrib. When the leaves are long and straight, the nerves are parallel the greater part of their length; when these nerves are close together, there are no secondary nerves to be seen, but when the limb is expanded, as in *Sagittaria*, *Canna*, *Smilax*, *Dioscorea*, &c., second-

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ary nerves are to be seen, and resemble those of the leaves of dicotyledonous plants or angulinerved leaves. Sometimes the primary nerves are more or less arched, diverging towards the extremity of the leaf; as, for example, in *Gincko*. In many succulent plants nerves have not been discovered; in that case the leaves are said to be nerveless or without nerves. The nerves are sometimes so much subdivided as to be termed reticulated.

*Simple leaves* are very variable in form, in consequence of their organization, but above all from the division and direction of the nerves; for if the secondary nerves are equal on both sides of the midrib, the leaves are usually regular, but in *Begonia* one side of the leaf is less developed than the other in a remarkable degree. A leaf is simple when the limb is entire, or when it is divided into lobes that are not articulated to the petiole. Every nerve ought to be considered as surrounded with parenchyma, which, if extended sufficiently between the nerves, they are completely united, even to their extremities. The leaves are then said to be entire; but when the nerves are more dispersed, and the cellular tissue is comparatively less extended, the connection of the parenchyma is imperfect, and consequently produces lobes and holes in the middle of the leaf, as in *Dracontium pertusum*, or teeth and lobes in the circumference. The Palm seems an exception to this theory of the formation of lobes, for they are seen to divide gradually from the extremity to the base of the limb, for the divisions adhere by a kind of down, and are therefore never intimately connected. When the parenchyma is not complete between the secondary nerves the limb is composed of many distinct parts, united only by the primary nerve which bears them. These lobes or portions are named segments, which differ from the leaflets of compound leaves, because they are not articulated and caducous. The leaves divided into segments are said to be dissected; if the lobes are joined towards the base about the origin of the nerves they are called partitions, and the leaves parted; if the lobes are joined to their middle they are called divisions, and the sinuses between them the fissures, and the leaves are then said to be cleft; finally, if the juncture of the lobes is complete, and that the parenchyma is separated only at the extremity, the leaves are then termed toothed or crenated. The terms given to leaves are indicated by their nervation, so that a feather-nerved leaf is called pinnatecut, pinnateparted, pinnatifid, according to the depth of the fissures between the lobes. Palmatenerved leaves, pedatenerved leaves, in the same manner, are said to be palmatifid, palmateparted, peltatecut, peltateparted, pedatifid, pedateparted, trisected, trifid, tripartite, quinquefid, &c. The lobes are sometimes again divided in a manner analogous, and the leaves are then said to be bipinnatecut, bipinnateparted, bipalmate, &c.; but if these lobes are again subdivided, the leaves are termed tripinnatesected, tripinnateparted, tripalmateparted, &c. The terms decompound, multifid, or dissected never have a precise signification.

*Compound leaves.*—Leaves are said to be compound when they bear leaflets on both sides of a common petiole, as *Robinia*, or at its extremity, as Trefoil, Orange, and some Palms. These leaflets differ from segments of simple leaves in being articulated upon the petiole, the disposition of the nerves. Sometimes in compound leaves, as in *Gleditschia*, the leaflets are often united by the parenchyma. The distinction between simple and compound leaves is not of so much importance as is generally believed; for a compound leaf may appear simple when only the terminal leaflet is present, as in the Orange, Lemon, &c.; but the articulation by which it is attached to the petiole is always evident, and by which it separates at a certain time. The leaflets may be said to be feather-nerved, considering the common petiole as the primary nerve, and the midribs of the leaflets as the secondary nerves, just as if it was a simple leaf. Leaflets are usually opposite along the common petiole, and are said to be in pairs; generally there is a terminal leaflet; in this case the leaf is then said to be impari-pinnate; but when there is no terminal leaflet, the leaf is then called abruptly pinnate. Sometimes a compound leaf is terminated by a tendril or point instead of a leaflet, as in some species of *Bignonia*. The leaflets are often subdivided into other leaflets, and in these cases the leaves are denominated bipinnate, tripinnate, bipalmate, &c. The stalks that bear the first divisions or leaflets are termed petioles, and the stalks of the further subdivisions are called petiolules.

*Disposition of leaves on the stem.*—The first leaves developed are the cotyledons, afterwards some leaves, usually of a peculiar form, called primordial leaves, and finally those of the ordinary form. The leaves which are nearest the flowers are often of a different form and colour to ordinary leaves. The first leaves, called radical, as rising from the root, are usually larger, on longer petioles, and of a rounder shape than those of the stem or the branches. The floral leaves or bractea are on the contrary smallest, usually sessile, more pointed, and generally of a different colour from the ordinary leaves. Leaves are either placed opposite each other, or in whorls, or singly; they are then said to be alternate. In the same family opposite verticillate or whorled leaves are to be found, and therefore opposite leaves may be considered in the light of a whorl of two leaves, as there is often found three leaves in a whorl on the same branch, where opposite ones is the ordinary disposition. Sometimes leaves are twin, that is rise from the branch together, as in numerous species of *Solanaceæ*; this may be considered as accidental, as they are to be found in species where a different kind of disposition is present. The pairs of leaves which succeed each other on the branch usually cross in such a manner that the third pair has the same direction as that of the first, and the fourth the second, &c.; but in some rare cases, as in *Globulea obvallata*, it is the sixth or seventh pair that recovers the direction of the first. The disposition of pairs and whorls is constant in the following cases: firstly, in the first leaves or cotyledons; secondly, when the leaves which compose a pair or a whorl are connected by their bases; thirdly, when they are united by a swelling of the stem or branch in the form of a bridle; fourthly, when the branches or stems present angles and faces in relation with the position of the leaves: *Labiatæ* are good examples in the two last cases. When the leaves are solitary, they are said to be alternate, a term not always proper, since leaves are rarely situated alternately on both sides of a branch in the same line. In most cases, when situated in two ranks, the third leaf recovers the direction of the first, the fourth the second, &c.; they are then said to be distinct. They are more often, however, disposed in a quincuncial manner, the sixth recovering the direction of the first, the seventh the second, &c. That arrange-

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ment by five spires produces as many vertical ranks of leaves the whole length of the stem or branch; an arrangement very osual among dicotyledonous plants. Spires more spread than the preceding are also known where the fifteenth, twentieth, or even twenty-first leaf recovers the position of the first. The following are examples of the divers spires. 1. Where the second leaf recovers the position of the first, as the Bean, Pea, Vetch, and Vine; this is called distinct. 2. The third the first, as in *Cactus speciosus*, *C. triangularis*, *Aloe*, *Colchicum*, &c.; but this is very rare. 3. The fifth the first, as in the Pear, Apple, *Robinia viscosa;* this is rather common. 4. The eighth the third, as *Laurus nobilis*, *Genista tinctoria*, *Lilium*, *Aconitum*, &c.; this is the most common arrangement. The following are very rare: 5. the fifth the thirteenth, as in *Euphorbia Gerardiana*, *Sedum acre*, *Agave Americana*. 6. The eighth the twenty-first, as in *Isatis tinctoria*, *Aloe prolifera*, and the cone of *Pinus abies*. 7. The thirteenth the thirty-fourth, as in *Sempervivum arboreum*. 8. The twenty-first tha fifty-fifth, as in *Cactus coronarius*, *C. depressus*, *Pinus pinaster*, &c.

*Diversity of leaves at different periods of the plant's existence.*—Leaves first appear in the form of buds, either at the extremity of the young plants or branches, and in the axils of the already developed leaves, or accidentally io other places of the surface: these last are called adventitious buds; the first normal. A single bud contains numerous leaves differently arranged, but the lower ones always cover the upper, and serve as a protection to them. When the outer leaves are of the form of scales the bud is said to be scaly; sometimes these leaves are of the ordinary form, and the bud is then said to be naked. But the presence or absence of stipulas, and the mode of developement of the leaves, give place to other differences, which it is of importance to make known. A bud is called foliaceous or leafy when the leaves are sessile, and without stipulas, then the limbs form the buds; a good example of this will be found in *Mezereon;* and a bud is said to be petiolate when the petioles are dilated into scales destitute both of limbs and stipulas, and protecting the inferior leaves: example, the Ash, the Horse-Chestnut. A bud is called stipulaceous when the stipulas are free and envelope the young leaves. Sometimes a great number of stipulas without leaves are accumulated about the interior leaves, as may be seen in all amentaceous plants; even sometimes every leaf is enveloped by free or combined stipulas which are the leaves that form so much of the jointed cones, as in *Magnolia*. Fulceraceous buds are those where the stipulas adhere to the petioles or scales formed of these two organs badly developed surrounding the interior leaves, as in *Rosaceæ*. The envelopes of the buds offer differences still more important from the position and different form of the leaves from the interior ones. 1. When the leaves are flat, opposite, and face to face, as in the cotyledons of most plants, and also Misletoe. 2. When the leaves are folded once longitudinally in the line of the primary or middle nerve, as in palminerves, &c., they are said to be plicate in the bud, which is the most common form. 3. When the leaves are plaited or folded twice transversely, so that the apex touches the bese, as in the leaves of Aconite, they are termed replicate in tha bud. 4. When the leaves are rolled up the extremity in the centre, as in *Cycadeæ*, *Filices*, *Droseraceæ*, they are then called circinnate or involute; but when plicata leaves are placed in a manner that the exterior face of the one touches the outer side of the other, they are then said to be conduplicate in the bud, as in Roses and Plums, and in these the leaves are always quincuncial. If leaves of the same nature are opposite, and the one completely embracing the other to which it is opposite, as is seen in Iris and the Whortleberry, they are termed equitative; but if one side of a leaf is placed in the fold of the opposite one, it is said to be half embracing, as in *Lychnis*, *Saponaria*, &c. When the edges of leaves are rolled inwards, they are said to be iovolute, and when outwards revolute; and when they are rolled one upon the other, they are then called supervolute, as in the Apricot.



*The duration of leaves.*—Bud leaves or scales very soon fall off. The fall of leaves may be attributed to many causes; the principal appear to be, first, the arrangement of the elementary organs at the base of the petiole, which renders that base more or less brittle; secondly, the weight of the leaves; thirdly, the extension of the surface, which causes more or less action by the wind; fourthly, the buds, which in the month of August become large in the axils of the leaves; fifthly, the increase in the diameter of the trunk, which extends and disunites the fibres by which leaves adhere to the branches. Leaves, which are said to be persistent, or those that are called evergreen, as in the Cherry, Laurel, Cork-tree, Evergreen Oak, Laurestinus, remain two or three years, or sometimes only one year, as the old leaves always fall as soon as the young ones are properly formed.

*Stipulas.*—On both sides of each leaf on the branches of many plants are small organs analogous to leaves, but of which their nature is less known; these are termed the stipulas; but they are absent in a great number of plants. Sometimes stipulas are equally developed with leaves, as in *Lathyrus aphaca; Rosaceæ*, *Leguminosæ*, *Rubiaceæ*, &c., have stipulas, while *Ranunculaceæ*, *Myrtaceæ*. *Solanaceæ* are without. Their nature is almost uniform in each family; they are as hard as scales in *Amentaceæ*, and foliaceous in *Malvaceæ*, &c. Stipulas are either entire or lobed, or diversely lobed or jagged; they are caducous in some families and persistent in others, and, like the leaves, their nerves are either feathered or palmate, but not so strong, and they are also furnished with stomata. They are sometimes transformed in spines, or into very slender threads; they are often combined with the leaves, and not with the stems, which shows that they are intimately connected with these organs, and may be considered as accessory to them, and not as some botanists have regarded them, as distinct organs. The stipulas are commonly borne at the sides of the origin of the leaves, while those of *Rubiaceæ*, *Loganiaceæ*, *Potaliaceæ*, and some other families, are borne toward the interior of the leaves, between tha petioles and the branch. This augments the appearance of the number of intraaxillary or intrapetiolar, or intrafoliaceous stipulas. Frequently the two lateral stipulas are prolonged, and adhering between the leaf and the branch, as in *Melianthus major*, or the two lateral stipulas are joined, which is demonstrated by tha circumstance of those in other species of the same genus being distinct.

In *Polygoneæ* the stipulas are combined between the leaves and the branch, and therefore entirely surround the branch, sometimes in the manner of a sheath, as in

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the Dock, and sometimes in a more evident collar, as in *Polygonum*: this last is called the ochrea in *Polygoneæ*. In grasses there is a small membrane called the ligula, which is produced by the prolongation of the sheath between the limb and the culm, which has been considered by some authors as a kind of intraaxillary stipula. The frequent adhesion of stipulas between each other, and with the petioles, is what modifies their form and appearance. When leaves are opposite, it sometimes happens that the stipulas of one side of a branch adhere to that of the other, so as to appear but one stipula on each side of every pair of leaves, as in most *Malvaceæ*, *Rubiaceæ*, certain *Astragali*, *Magnolia*, some species of *Ficus*. The stipulas which jut out from the side opposed to the leaf, and adhere to the other side of the stem, in such a manner as to envelope it by their bases, are then said to be oppositifolius, or opposite the leaves. Finally, in *Rosa*, for example, where the stipulas adhere to the petioles, they are called petiolar, while those that do not adhere to the petiole are said to be caulinary. At the base of leaflets in compound leaves there are often small scales or membranes which are called stipels, the lateral leaflets are furnished with one of these, and each terminal leaflet with one on each side, as in most *Leguminosæ*.

*Of accessory appendages of the axis.*—Spines and tendrils are modifications of leaves or stipulas. Tendrils are generally long and filiform, either simple or branched, so as to support the stems or branches of the plant, which are always climbing when tendrils are present. Tendrils are said to be petiolar when they are an elongation of the petiole, as in *Vicia* and *Clematis*; when they are an elongation of the leaf, as in *Gloriosa superba*, they are said to be foliar. This is frequently the case in compound leaves; but when they are in place of stipulas they are then said to be stipular. In the Vine, where they are evidently modified peduncles, they are said to be peduncular. In *Fritillaria* the bracteas change to tendrils; in *Calytrix* the sepals; and in *Strophanthus* the petals. Spines are indurated points which protect plants against attacks, and are therefore called the arms of plants; they are generally of two forms, known by the names of prickles and spines; the former are nothing but enlarged indurated hairs, as in the Rose, Cactus, &c.; these organs are found in all parts of a plant. Spines, on the contrary, are modifications of branches, petioles, &c.; for instance, *Gleditschia* and *Cratægus* have branches transformed into spines. Some species of *Astragalus* have the petioles hardened into spines, and these are called petiolar spines. The *Pictetia* and some Acacias have the stipulas changed into spines; they are therefore said to be stipular. The nerves of leaves and leaflets are sometimes hardened into spines, as in the Artichoke, Cardoon, &c. The involucra in some *Compositæ*, the bracteas of some *Acanthaceæ* are transformed into spines; the peduncles and pedicels of *Alyssum spinosum*, *Mesembryanthemum spinosum*, the sepals of *Stachys*, the petals of *Cuviera*, the stamens of some *Ericaceæ* and *Byttneriaceæ*, the styles of *Martynia*, are transformed into what are termed spines.

*Of inflorescence, or arrangement of the flowers on their axes.*—If phænogamous plants are to be considered in all their generalities, it will be found that they are formed of organs which are capable of extending themselves indefinitely according to the degree of vital energy peculiar to each species or individual. Roots grow indefinitely; branches have no necessary limits: leaves are arranged in spires, a kind of curve which may by its nature be prolonged indefinitely. But if vegetables are constructed upon a plan which in theory has no necessary limit, there is nevertheless a termination to each organ, and the spire of the leaves, as well as the stem and branches, stop at a certain point; this point is commonly in the centre of a flower. It happens that at the extremity of the spire the leaves assume varied and special forms, which together form the different parts of the flower and its appendages, such as bracteas, sepals, petals, stamens, ovaries. All these leaves of a particular nature approach so very closely together that the turns of their spires appear only like verticils. The point even where the stem and the spire are stopped cannot be discerned, owing to the extreme proximity of the parts; the axis of the flowers of *Geum rivale*, some species of *Rosa*, and other plants is frequently observed to be accidentally prolonged into a branch covered with leaves, clearly demonstrating that the generation of organs beyond the flower is not impossible, that the curve along which they originate do not close like a circle, but that it is only stopped in its indefinite developement. Formerly botanists were content with describing the inflorescence in a vague manner, founded on its general form only; but several acute observers, and especially Dr. Rœper, have more recently introduced a more accurate and philosophical mode of considering this subject. The stem, or every branch that bears a flower, is regarded as the primary axis of inflorescence; if this axis divide into branches which rise from the axis of leaves and bear flowers, the inflorescence then possesses a secondary axis; and if these divisions bear leaves which give birth to other subdivisions proceeding from each axil, these last are called the tertiary axis, &c. The support of each flower may be the degree of subdivision of the inflorescence and is termed the pedicel, and that of the anterior division which bears several flowers, leaves, and pedicels, is called the peduncle. The peduncles are generally the secondary axes, and pedicels the tertiary; these supports vary in length, and are sometimes so small that they may be said to be wanting, and the flower is then termed sessile at the summit of the peduncle, (if the pedicel is wanting,) or sessile on the stem itself, if both peduncles and pedicels are wanting. The degree of subdivision of the branches is indicated by the number and position of the floral leaves or bracteas, for every axis whatever proceeds from the axil of a leaf. The numerous forms or varieties of inflorescence may be almost all included in two classes, namely, the definite or determinate, and the indefinite or indeterminate. Definite inflorescence is that form in which the primary axis is terminated by a flower, in which case the secondary, tertiary, &c. axes are similarly terminated; for it is a rule without exception that the transformation of leaves into floral organs commences at the extremity of the axis the furthest removed that are found on each inflorescence; that is, the flower that terminates the primary axes first expands, then those that terminate the secondary axes, and then those that terminate the tertiary axes; then follow the lateral flowers, opening as they descend: this order of expansion is called centrifugal. The various forms of determinate inflorescence are as follows: 1. uniflorous, when a stem, plant, or branch is terminated by a single flower; 2. cyme; the branches which are situated near the terminal flower, and which are usually opposite or verticillate, give origin to second-

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ary axes, which may in like manner have tertiary ones issuing from the axils of the bracteas. When the bracteas are only two in number and opposite, the cyme is dichotomous, as may be seen in *Dianthus*, &c. A cyme may be trichotomous, tetrachotomous, pentachotomous, according as it has three, four, or five bracteas, and verticillate branches at each division, of which examples of all are to be met with in *Euphorbia*. It may happen that one of the divisions of a dichotomous cyme is never developed, then the flowers are found on one side of the branches, usually on their inner side; more often the tertiary axes are those that are developed in this unequal manner; this variety is termed a scorpoid cyme, and occurs in *Drosera, Echium, Sedum*, &c. When the floral leaves are alternate, the branches are alternately developed, so that there is found at each leaf a single flower which terminates the axis, and between the leaf and the flower a lateral branch; it is from this cause that the flowers appear opposite the leaves, as in *Nemophila pedunculata, Solanum*, &c. A tuft, or fascicle, or contracted cyme, is a cyme the lateral branches of which are very short, as in *Dianthus barbatus*, &c. *Statice, Armeria*, &c. Glomerule is a cyme so contracted that the flowers are sessile; this is a rare case, but is found in *Corymbium* and *Cardopatum*.

*Of indefinite or indeterminate inflorescence.*—In this class of inflorescences the primary axis is never terminated by a flower, for the spire of leaves stops without being transformed into a flower. In the indefinite inflorescence the expansion of the flowers proceeds from the base gradually towards the top, and is therefore called centripetal. The varieties of this kind of inflorescence are the following: 1. a single flower issuing from the axil of one of the leaves; in descriptions this is often confounded with the determinate one-flowered stem. 2. Spike is formed of a number of sessile flowers issuing from the axils of leaves or bracteas, as in *Plantago, Veronica*. A spike is said to be compound when it divides at the base or at the top into several similar spikes, which may be regarded as secondary axes. A spike is said to be crowned when the central axis is prolonged upwards without bearing flowers, as, for example, in Pine Apple, *Eucomis, Callistemon*. 3. Catkin or amentum is a spike composed of either male or female flowers only; the former withers and falls off after flowering. This occurs in amentaceous orders, as in Oaks, Willows, Walnuts, Filberts. 4. Cone or strobile, frequent in *Coniferæ*, is a spike in which bracteas become hardened, persistent, overlie each other like scales or the tiles upon the roof of a house; this only applies to the female spikes, the male differing in no respect from the catkin. 5. Spadix is a spike enveloped by a large sheathing bractea, as in *Arum, Richardia, &c.*; in Palms the spadix is mostly branched, and enveloped by an immense bractea. 6. Thyrse is a spike in which secondary branches are developed, and terminated by a flower. At the axil of each leaf of the central axis an odd number of flowers is to be met with, of which the terminal one expands first; this kind of inflorescence is composed of cymes or fascicles arranged along an indefinite primary axis, as in *Lobiatæ, Salicareæ*, some *Campanulæ, Rhamneæ*. In all cases the flowers expand from the base; sometimes, as in Horse Chestnut, the base of inflorescence is a thyrse and the top a spike. 7. Raceme or cluster has the lateral axes more or less developed, and the secondary axes terminated by a flower; it is said to be a simple raceme when the secondary axes are reduced to a single pedicellate flower, which should be accompanied by a bractea, showing that the flower should indicate a tertiary branch. A raceme is said to be compound when the number of subdivisions is greater; a raceme may be compound at the base and simple at top. 8. Corymb is a raceme, the lower lateral branches of which are very long, and the upper very short, so as to be nearly on a level, although the branches proceed separately from different points of the axis, as in *Iberis, Ornithogalum*, &c. 9. Umbel is a raceme the branches of which proceed in the same order from the apex of that whence they originate, all the branches which proceed from the same point being a little different in height; the flowers are placed on a concave, flat, or convex surface in different species of *Umbelliferæ*. An umbel is said to be simple when the secondary axes are not subdivided, as in *Hedera, Astrantia, Hydrocotyle, Eryngium*; and it is said to be compound when the secondary branches divide themselves into little umbellules as in most *Umbelliferæ*. 10. Head or capitulum, of an indefinite inflorescence, is when the flowers are sessile and agglomerated into a head on a very condensed or shortened axis. A capitulum may be either ovate, rounded, or depressed, according as the axis is more or less shortened; this axis is named the rachis by some, and the receptacle by others. The small condensed flowers are termed by many florets, and the bracteas that surround them a common calyx; each floret proceeds from the axil of a bractea, which appears in the form of chaff, and it is often absent, or appears in the form of a little pit or hollow, which is commonly fringed at its edges. Examples, *Compositæ*.

*Anomalous inflorescence.*—The doubtful origin of some peduncles, the unequal developement of the branches of the axis, their connection with other organs, together with their own transformation, often conceal the true nature of certain varieties of inflorescence. When the floral axis issues from the base of the plant, or from that portion of the stem placed under ground, the inflorescence appears altogether singular. In this case the peduncles only bear bracteas, and these only at great intervals. This is what constitutes a scape, as in the Primrose and Hyacinth. The developement of the axis may be unequal at the point where two branches ought to issue from a pair of bracteas, one of them remains undeveloped, or less so than the other. When the floral axis becomes united or combined with the axis of the plant, the flowers appear to issue from above the axil of the leaf, and is then termed extra-axillary, as in *Capparis spinosa*, some species of *Solanum*. The inflorescence is petiolar when the peduncle is united with the adjoining petiole, as in some species of *Hibiscus*; sometimes it combines with the bractea, as in *Tilia*. The ramifications of the axis may combine together, as is often seen at the base of several racemes or spikes, as in *Celosia cristata*, &c., and in those monstrosities of *Sedum, Fraxinus, Campanula*, and *Cichoraceæ*, termed fasciated stems or branches.

*Of the rachis, or general floral axis.*—The rachis is not a particular organ, but an expansion arising from the concretion of the ramifications of the axis; in proportion as the flowers are congregated in one point this part becomes thicker and more fleshy. In *Compositæ*, where the rachis is always thick, it performs an important function of vegetation. It serves as a depôt of nourishment for the flowers and ovaria. In the Artichoke this part is so much increased as to become an article of



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food; after flowering the rachis gradually dries up, contracts, and thereby facilitates the expulsion of the seeds. In the Fig, the rachis, which is called the fruit, is concave, and encloses completely the flowers and fruits, which last are found in great numbers under the form of small gritty grains; this rachis when mature opens spontaneously on the upper side. *Dorstenia* has a hollow but not closed rachis intermediate between the Fig and that of *Compositæ*. In *Procris, Elatostemma*, and various species of *Bœhmeria*, are to be found intermediate gradations between this form of rachis and the thyrse or spike, showing that it originates from the concretion of the secondary axes with the primary one.

*Of bracteas.*—These are leaves more or less modified, from the axils of which proceed the floral axes, which are sometimes not developed, when the bracteas are said to be sterile; they are often highly coloured, exceeding in brilliancy the flowers themselves. As in some species of *Euphorbia, Mussænda, Combretum*, &c., the transition from perfect leaves to bracteas is readily seen by proceeding from the base of the stem to the floral axis. The bracteas of secondary and tertiary axes are called bracteoles.

*Of the involucrum.*—When bracteas are verticillate, as happens in certain kinds of inflorescence, as in *Umbelliferæ, Compositæ*, or where they are combined together, as in *Ranunculaceæ* and *Nyctagineæ*, &c., then they form what is termed an involucrum; and those occurring under the same disposition in the secondary or tertiary axes, as in the compound umbel, they then become a partial involucrum or involucel. The involucrum is either composed of a single verticil or several verticils, and is then called a uniserial, biserial, triserial, and pluriserial; and when the outer series is very short the involucrum is termed caliculate, because it resembles a calyx. The involucrum, like other bracteas, is often highly coloured, as in *Astrantia, Buginvillea, Abronia*, &c. When combined, it is liable to be mistaken for a calyx, particularly if it contain only a single flower, as in *Mirabilis*. The most remarkable of these concrete involucra is the cup or cupola of the Oak, or acorn, and the spiny envelope of the Spanish Chestnut and Beech, and the concave one of *Euphorbia*.

*Of the spath.*—The spath is a form of bractea peculiar to the monocotyledonous plants, being alternate and enveloping the axis. It is foliaceous in some *Irideæ, Asphodeleæ, Commelineæ*; coloured in *Aroideæ, Musaceæ, Richardia, Heliconia*, &c.; those which occur at the base of the secondary or tertiary axes are called spathels; in *Gramineæ* and *Cyperaceæ* they are called glumes and glumels. Bracteas form the transition from ordinary or perfect leaves to those which compose the flowers, as sepals, petals, ovaria, &c.

*Origin, nature, and disposition of the parts of which a flower is composed.*—A flower is the reunion of organs, such as the germs and those that surround them, and is composed of a peculiar transformation of leaves borne at the tops of the stem or branches which are usually disposed in regular whorls; that part of the stem or branch which bears the organs of a flower is denominated the torus, and which, if elevated in the centre of the flower, is called the receptacle. The verticils are extremely variable in number, and have a great tendency to combine, and their form is far removed from that of leaves or bracteas, and situated more towards the centre. From their appearance and position they are divided into four classes, the calyx, the corolla, the stamens, and the carpels or ovaries, and ovules. The calyx and the ovaries are composed usually of a single verticil; but the petals and stamens are often of numerous verticils alternating with each other; each verticil is generally composed of five pieces in dicotyledonous plants, and three in monocotyledonous plants.



*Of the calyx.*—The sepals form the outer or primary envelope of a flower, and is called the calyx. The analogy of sepals to leaves is evident, as in the greater number of plants they are flat, foliaceous, and of a green colour, and are furnished with stomata inside; they are often accidentally transformed into leaves, as in some Roses. Their nervation is also similar, usually feather-nerved; the middle nerve is said to be carinal, and the juncture of two neighbouring sepals is called sutural. Like leaves sepals are persistent or caducous, and if they remain and become dry after florescence, they are said to be marcescent; and if they increase and become fleshy they are said to be accrescent. They are more frequently joined together, the calyx is then termed gamosepalous; when they are combined to their apices the calyx is entire. Sometimes the calyx breaks off at the base in one piece, as in *Eschscholtzia, Eucalyptus*, and sometimes by the middle, as in *Scutellaria*. The part of sepals which is combined is termed the tube, and the free parts the lobes, and if short the teeth; sometimes the junctures are very unequal, so as to leave more space between certain lobes, the calyx is then said to be lipped or bilabiate. In some plants, as in *Acanthaceæ*, the lobes of the calyx become as hard as spines. In the *Compositæ* the tube adheres to the ovarium, and the limb is like the crown of a heron, formed by the lobes being changed into hairs, and this is called the pappus. In dicotyledonous plants there are usually five sepals, or if the sepals are joined the calyx is five-lobed or five-toothed. Sometimes there are three, more rarely two, four, six, &c. In some plants, as in *Potentilla, Fragaria*, and divers *Malvaceæ*, the calyx is furnished with appendages outside alternating with the sepals, which are generally called accessory lobes, but they are regarded as stipulas to the sepals joined by twos; in others the calyx, as in many *Campanulaceæ*, has appendages which are recurved back upon the tube between the lobes like auricles; this is evidently occasioned by a strange prolongation of the sepals or calyx.

*Of the corolla.*—Just within the calyx are found the petals, which, taken collectively, are called the corolla. Petals are more distinct from leaves than sepals; they have fewer stomata; their nerves are analogous to that of leaves for direction, but are weaker, and contain no vessels but tubes. The petals are of all the most brilliant colours in preference to green, which characterises the leaves; they usually exhale odours which are generally agreeable. But these differences of petals from sepals and leaves are not always evident, for sometimes the sepals and petals resemble each other so much that it is difficult to say where the calyx ends or the corolla commences, as in *Nymphæaceæ, Magnoliaceæ, Ranunculaceæ*, &c. There is one thing which renders these distinctions difficult, that in many cases the sepals or the petals are absent in some flowers. The analogy of neighbouring species or genera is probably the only means of indicating in this case the real nature of the floral envelopes. The petals are frequently joined altogether or in part, the corolla is then termed monopetalous, or, more lately, gamopetalous by De Candolle. When the petals are completely joined, the corolla is an

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entire tube, but when they are only combined more or less, the corolla is said to be cleft, lobed, or toothed, according to the degree of connection between the petals. In *Phyteuma* the petals do not adhere at the middle, but by the base and apex; and those of the Vine are connected by their summits only. In some *Compositæ* they are joined only on the inner side of the capitulum, but in those that form what are called ligulate flowers or florets have the tube cleft lengthwise. Sometimes certain petals are joined more than others in the same flower, and thus form the lipped or bilabiate corolla. The position and direction of the primary nerves in monopetalous or gamopetalous corollas being in the centre of the lobes, similar to those in separate petals, are sufficient evidence to show that monopetalous corollas are composed of combined petals. The petals or lobes, when equal in number to the sepals or lobes of the calyx, generally alternate with them. Sometimes monopetalous corollas change accidentally into polypetalous ones, and therefore the petals manifestly hold the place of lobes in monopetalous corollas. In the corolla called papilionaceous, as that of the Pea, the Bean, and most *Leguminosæ*, each of the five petals are of a different form and size, and arranged in such a manner, as to give each flower the appearance of a butterfly; the upper petal is much spread and raised, is usually the largest, and is named the standard; the two lateral ones, which are smaller, oblong, and placed face to face, are called the wings, and finally, the two lower ones being more or less raised up, particularly at the points, and form something like a crescent, and are joined more or less on the lower edges, in the manner of a keel, and are in conjunction termed the carina or keel; these latter are seldom free. The standard and wings are seldom joined, and then very imperfectly towards the base. There is nothing to distinguish petals clearly from sepals in some dicotyledonous plants; they are ordinarily five in a verticil, which is, perhaps, composed of one horizontal spire; sometimes the number differs, as three, four, six, seven, which is probably composed of several concentric verticils; in this latter case the petals of one verticil generally alternate with those of the next, and when there is found two ranks of petals which oppose each other, it is to be presumed that the intermediate verticil is not developed. The junction of petals are principally among those of the same verticil; but there are found examples in which two neighbouring verticils are joined, as in *Annonaceæ*, where there are six petals joined, while there are only three lobes to the calyx, and the verticils being always three in the rest of this family. When the petals are contracted at the base and spread out at top, the contracted part is called the claw, and the enlarged or spread-out portion the limb or lamina. Gamopetalous corollas, and those that have the claws straight, and approach each other without being joined, are said to have a tube, a throat, which is the entrance to the tube, and the lobes or limb, which is the spread, or expanded, or superior part. Sometimes free petals bear scales at their base, as in *Ranunculus*, or small threads, as in *Samolus*, or a corona, as in *Silene*, and particularly *Stapelia*, or they appear in different strange forms.

*Of the stamens* or *male organs.*—Stamens or stamina are formed of one or more verticils on the inside of the petals, and are analogous to them in position and transformation. They are inserted upon the torus, very close to the petals, to which they sometimes adhere, and are often accidentally transformed into petals in the flowers which are called double, as, for example, in all double Roses, in which the stamens are the only parts changed into petals. When there is only a single verticil of stamens, they are usually equal in number to the petals with which they alternate. In some families, as *Primulaceæ* and *Myrsineaceæ*, they are opposite the petals; and always where this is the case, it is supposed that the primary verticil of stamens, or those which should have alternated with the petals, are abortive, of which traces are to be found under the form of scales or threads. When there are a number of verticils of stamens, each of them is composed of the same number of parts, that in short the total number of stamens is only a multiple of the number of petals; as, for instance, in a flower where the petals are five, or the corolla five-lobed, the stamens are either five, ten, fifteen, twenty, &c.; and three, six, nine, twelve, in flowers which have three petals or a three-lobed corolla, &c. When the number passes twenty it is rarely that botanists give themselves the trouble of counting further. The organization of stamens is more complicated than either sepals or petals; they are not envelopes to protect the organs of reproduction, but have in the fecundation of vegetables the functions of male organs. Each stamen is composed of a filament at the base and an anther on the upper part, which contain the pollen in its cells.

*Of the filament.*—A filament may be considered in the same light as the petiole of a leaf, or the claw of a petal; it is usually cylindrical, but sometimes flat, and always of a consistence and nature analogous to a petal, and never of a green colour. In some plants it is so short, or joined with the corolla, that the anther is said to be sessile. The stamens in the same verticil are sometimes joined together, and sometimes with the neighbouring verticils. When all are joined, as in Mallows, the stamens are termed monadelphous; but when they are joined into two, three, or more bundles, they are called diadelphous, triadelphous, and polyadelphous.

*Of the anther.*—An anther may be viewed in the same light as the limb of a leaf or petal, but is usually small, generally narrow, thick, and divided into cells or small cavities containing the pollen. A regularly formed leaf consists of a central rib, on each side of which there are twofold cellular tissue, between which the nerves take their course. In this manner are the anthers naturally formed, whose superior and inferior cellular tissue is converted into pollen on both sides of the principal nerve; thus is formed the anther with four cells, which is found to be the general law. Dr. Schleiden found the anther before its bursting four-celled in more than one hundred families. It has been often asserted that the anther could not be originally four-celled, since it springs open with two fissures only. Properly speaking, every anther bursts open with four fissures; they appear, however, only as two, because each pair lies at the sides of the common septum. When the lateral half of a leaf is only developed, the other retains its leafy character. Sometimes the original middle layer is not developed, in which case the division into two lateral cells is not found in every family; even in *Orchideæ*, *Asclepiadeæ*, *Stylideæ*, &c., as far as its first appearance, goes through just the same conditions, and that all apparently deviating characteristics of this organ in the before-mentioned orders are merely later unfoldings of the same fundamental type, and are only physiologically



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unimportant modifications of the same plan. There are three positions in which the anther is attached to the filament; first, by the middle of its length, the anther is then said to be versatile or oscillatory; second, by the point at the base to the tip of the filament, and is the mode called erect; thirdly, it adheres to the filament the greater part of its length; it is then termed adnate: in the latter case the filament is often prolonged beyond the anther, where it forms a point, tongue, or gland. The anthers are said to be synantherous when they are joined into a tube, as in *Compositæ*. In some few cases, as in *Salix monandra*, both filaments and anthers are joined into one. The cells of the anthers are ordinarily parallel, open at a certain era and emit the pollen. The portion of the filament which unites the two cells, or rather the two double cells, is called the connective; this part is sometimes very short, and sometimes so long as to separate the cells, as in Sage; sometimes it is articulated upon the filament in such a manner as to appear a distinct organ; but usually it is not distinguishable. The anther which has an articulated connective may be compared to the terminal leaflet of a compound leaf; in all other cases the connective resembles the primary nerve of a leaf, while that of the cells seem to be the parenchyma with the lateral nerves hardly developed, but sometimes there are in the interior of the cells partitions which may be regarded as analogous to secondary nerves. Anthers are generally said to be two-celled, but according to the observation of Dr. Schleiden there are two cells on each side, which has already been explained; however in the characters of plants an anther of four cells is always said to be two-celled; and where the anther bursts by two clefts it is said to be birimose, which is the most common mode of dehiscence. But in *Solanum* the cells do not open except at the extremity. In many *Melastomaceæ*, *Ericaceæ*, the cells are prolonged into points, which open each by a pore at the extremity; this mode of dehiscence is called biporose; in Lavender it is composed of transverse clefts; in *Berberis* and *Laurineæ*, &c. it opens by valves. If the cells open to the outside of the flower the anther is said to be extrorse, behind, or postic, as in *Pæonia*, *Magnolia*, but in most cases they open inwards; the anther in that case is called introrse in front or antic, even if the anther is situated inside the filament. It is sometimes the case that one of the cells is abortive or not developed, as in *Epacrideæ*, *Canna*, &c.

*Of the pollen.*—Pollen is composed of a multitude of small grains of a yellow-orange or reddish colour, usually in the form of powder, in the interior of the cells, and which by its fall and action upon the stigma determines the developement of the ovules. The grana pollinis, or grains of pollen, appear an agglomerated mass filling the cells of the anther, even at its birth, without being intimately connected with their endothecium. The formation of pollen takes place in the following manner, according to the observations of Dr. Schleiden: the four groups of cells intended for the pollen separate themselves from the remaining tissue of the leaf, their individual cells continually increasing, and in the interior of each, probably for the most part, four other cells are formed, in each of which a grain of pollen is produced, upon which the original cells become entirely reabsorbed. The four pollen grains often appear to be developed in one cell; sometimes, though rarely, there are only two grains of pollen found in the larger original cell, for instance in *Podostemon*, *Ceratophyllum*, which in that case afterwards remain adherent one to the other; yet the quadruple number is undoubtedly the general rule, which explains the frequent occurrence of pollen quaternarium, or pollen by fours. If, however, the reabsorption of the original cells does not take place, or is not perfect, a very peculiar arrest of developement occurs, which being the constant type in *Orchideæ* and *Asclepiadeæ*, has afforded botanists abundant occupation, whilst the entire peculiarity consists in this, that the pollen stops short at an earlier point in its developement. This same condition may be seen as a temporary stage in the developement of the flower of *Picea* and *Abies* in January and February, in *Pinus* in February and March, in which a loose waxy pollen mass may be found imbedded in each division of the anther. At a somewhat later period may be seen the four cells in *Picea* and *Abies*, in which the four grains of pollen lie closely united; and it offers a very pleasing spectacle when observed under a microscope, each grain expanding by the absorption of water until it bursts its case in order to escape, leaving the four cells emptied of their contents. Pollen grains are globular, elliptic, prismatic, or polyedrous in form, smooth or scabrous on the surface. The grain of pollen falling upon the stigma, which is covered with a clammy liquid, the inner membrane issues quickly, which it does even by coming in contact with water, as has already been observed, under the form of a tube, either at certain determinate points, or at any one point of the exterior envelope; this tube contains the liquid called fovilla, in which floats an infinity of minute granules. The issuing of the inner membrane of a pollen grain is occasioned by the physical effect liquid has upon some point of its surface. They seem to issue in various ways, according to their shapes. M. Fritzche has distinguished thirty-four different varieties of pollen masses, besides those of *Orchideæ* and *Asclepiadeæ*.

*Of the fovilla.*—This is the clammy liquid with which the inner membrane of the pollen grain is filled; it is always in motion, and does not mix well with the liquid in which a grain of pollen is placed for the purpose of examination. Some molecules, larger and of different shapes, are found mixed with the granules which have less motion. The granules vary in form in different plants, but are similar to each other in the same species; they are either spherical, elliptical, or cylindrical, and variable in size. These granules are the essential agents of fecundation. Mr. Brown having discovered that the molecules of all bodies, even minerals, have analogous movements when they are reduced to an extreme tenuity, and therefore this phenomenon does not depend upon organization, and consequently forms a separate department of natural history.

*Of the ovarium, pistil, or female organ.* — The centre of a flower is composed of leaves more or less replicate on the inner side, and bear upon their edges ovules or ovula destined to become seeds. These leaves are called carpels, indicating that they are the elements of fruits: they are generally known under the more ancient name of pistils. When the number of these carpels are few, their position in the centre of the flower is more regular than that of other organs. They appear to be composed of one verticil, of which the pieces are in the normal state alternate with the inner row or verticil of stamens. Nevertheless the number of carpels are often fewer than the stamens of the inner row, or being

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equal in number the parts may be opposite. Sometimes the carpels are very numerous, and disposed in a spiral manner or in irregular heaps along the axis of the flower, as in *Ranunculaceæ* and *Magnoliaceæ*. The axis of the flower is the extremity of the pedicel, which gives birth to the organs of the flower, and is often more or less lengthened out, when this axis is stopped at the point where it bears the carpels, and sometimes it is elevated or prolonged, as in Ranunculus. In *Geraniaceæ* the carpels hang along the axis, but afterwards separate with elasticity from the base upwards. In *Magnoliaceæ* and some *Ranunculaceæ* the carpels are disposed in spikes upon the prolonged axis in great numbers; in the Strawberry this axis is fleshy, having the carpels disposed on its surface; in the Rose, on the contrary, this axis is secured in such a manner that the carpels are borne inside under the level of the stamens and petals, as if hidden in the bottom of the flower. These modifications bear only upon the elevation of the carpels, and not upon their relative position. If the carpels are elevated, the support is called the gynophore or theeaphore, which is sometimes many inches in length, as for example, in *Capparideæ*, but it is generally wanting, as the carpels are nearly always sessile. The carpels are swelled at the base, and this part is called the ovarium, and is the limb of a carpellary leaf in its broadest part, having the ovula arranged along both its edges, which are folded towards the centre of the flower. The ovarium is the object and aim of the entire vegetable organization. According to the generally received view the ovarium consists of buds or ovula, which develope themselves on the borders of the leaves or carpella, which is probably an incorrect notion, and has been adduced from the well-known phenomenon in *Bryophyllum*, *Gloxinia*, &c., but it would be better to consider such leaves as these dilated branches. Sometimes the ovules are represented as formed on the edges of the carpellary leaf, sometimes on the central nerve, and sometimes on both, and sometimes the entire surface of the leaf bear ovula, as in *Gentianeæ*, *Nymphæaceæ*. In this manner an extravagant view has been thrust upon the science, founded upon the weakest possible grounds, as has been detected by Dr. Schleiden, whose opinion is as follows. The explanation of the only contradictory fact of the parietal placenta by the assumption that the placenta is a formation of the axis, which indeed may be proved without the assistance of hypotheses from the well-known modifications of the stalk; each individual carpel is at first quite isolated, and constructed similarly to every young leaf. It is not until a much later period of their developement that it begins to direct its edges inwards, or the carpel is closed, or to adhere to the neighbouring edges when the pistil is unilocular and many-leaved. In *Gramineæ* and *Cyperaceæ* there is a deviation from the ordinary plan in both these families; their developement shows that the ovarium consists of one carpel only. In both families the two anterior stigmata for the carpel are merely a further developement of the ligula; the posterior, however, which is so often abortive in the grasses, is analogous to the surface of a leaf, and the ovarium itself to the sheath of a leaf.

*Of the ovarium.*—The ovarium is that portion of a leaf which encloses the ovula; as the style is that portion which is rolled up and does not develope ovula, and whose object is to conduct the prolongation of the pollen tubes; and lastly, the stigma is the free termination of the superior part, whose object is to receive and hold the pollen. In grasses stigmas are generally sessile, but *Lygeum* and *Zea* possess an actual style. In grasses, in most cases, although said to have one carpel and several styles, the styles so called are nothing but sessile stigmas, for no carpel is furnished with more than one style. A true style equally seldom occurs in *Euphorbiaceæ*, in which more than one style has been described; there is either none at all or sessile stigmas, but never more than a single style; the style is also deficient in *Malvaceæ*, *Alismaceæ*, *Phytolaceæ*, only possessing sessile stigmas. It is equally incorrect to speak of styles in *Compositæ*, which are only forms of a double-lobed stigma; in *Coniferæ* the carpellary leaf is not closed; in *Resedaceæ* three and four are united to form an open basin.

*Of the ovulum.*—A simple envelope to the ovulum is found under the following circumstances: 1. without the axis being bent, as in *Taxus;* 2. or else the axis is reflected upon itself, whereby the envelope becomes adherent to the prolonged axis; (raphe;) 3. there is a second covering formed which incloses the point of the axis, and here also both modifications may occur. The axis remains straight, as in *Polygoneæ*, &c., or else the axis becomes bent upon itself, adhering to the external integument. In monocotyledonous plants the seed or ovulum never possesses less than two integuments, while in dicotyledonous plants the majority of the monopetalous families is furnished but with one integument, whilst the polypetalous generally possess two. A central free placenta, or the axis on which the ovula are borne, is not a separate organ, but only the summit of the axis; but the formation of parietal placentas is not so easily understood, except they be considered as the branched summit of the axis. R. Brown, Brogniart, Amici, and Schleiden have thrown an entirely new light on the pollen tubes; Schleiden has followed them in upwards of one hundred different families with the most patient investigation, from the stigma into the ovulum; Mr. Brown has described more than one pollen tube as entering into one micropyle. Dr. Schleiden has observed two to three in many plants, as in *Phormium tenax;* three to five in *Lathræa squomaria;* scarcely ever less than three, and once even seven. If the pollen tubes be followed further into the ovulum, a process perhaps the most delicate that occurs in botanical investigations, it will be found that usually only one, rarely a greater number of pollen tubes, entering into the micropyle, penetrates the intercellular passages of the nucleus and reaches the embryo sac, which being forced forwards presses it, indents it, and forms the cylindrical bag which constitutes the embryo in the first stage of its developement, and consequently consists solely of a cell of leaf parenchyma, supported upon the summit of the axis. It is therefore formed of a double membrane, excepting at the open radicular end, *viz.*, the indented embryo sac and the membrane of the pollen tube itself. The process of developement of the embryo already described, easily establishes a unity of phænogamous and cryptogamous vegetation, in which the sporules are evident conversions of the cellular tissue of the foliaceous organs, since the same part in both furnishes the groundwork of the new plant in both groups; and the only difference existing between the two is this, that in phænogamous plants a previous formative process in the interior of the plant precedes the period of latent vegetation, whilst in cryptogamous plants the sporule, or pollen grain, developes itself to a plant without previous preparation. This process explains naturally the formation

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of buds on leaves, as being merely a partial retrogradation into a lower or cryptogamic organizatinn.

*Subsequent developement of the ovulum.*—Linnæus had a tolerable idea of the metamorphoses of plants, yet the introduction of this doctrine and its reception into higher botany takes its date from Goethe. Long, however, before Goethe, C. F. Wolff had shown how fruitful this idea could be rendered; but his work was not at all understood by the botanists of the time, and was therefore soon forgotten. But it has since formed itself into a peculiar department of scientific botany. A ripe seed presents the young plant already provided with manifold organs, and a much earlier period must be chosen; that of the first origin of the embryo upon its first appearance is recognised as a membranous cylinder, rounded and closed superiorly, but open inferiorly, since the membrane constituting the embryo is invariably continued into the sac containing it, and filled with organizable, usually pellucid fluid mass, which becomes gradually converted into cells, beginning from above downwards, during which process the cellular nuclei also become apparent, which appear at all times to perform a principal part in the formation of cells. At this point a leading phenomenon of vegetable life finds its explanation. The embryo originally consists of axis alone, and being closed superiorly only allows a further developement from within outwards; but if limited inferiorly, and by the secretion of organizable matter becoming transformed into cells, admits of unlimited prolongation; whence not only the direction, but the mode of the growth of the stem and root, differing as they do, become intelligible. During the second stage of the developement the upper end of the germ expands into a globular form, and from the sides of this globular extremity, in dicotyledonous plants, the two rudimentary cotyledons become developed as cellular projections, their points being more or less free. In them, as also in the stem itself, the elongated cells and spiral vessels are not formed until a later period. In monocotyledonous plants, on the other hand, a symmetrical elevation is formed at the summit of the cylindrical embryo, which ultimately constitutes the cotyledonous leaf surrounding the stalk, and which also subsequently encloses more or less the terminal bud or plumule. This process offers the second and greatest difference to which a plant can lay claim, namely, the antagonism between vertical, longitudinal, and horizontal superficial extension. All subsequent developement of the plant and every later formed organ are only modifications of these two portions of the axis, the stem, leaves, &c.; indeed, the axis is formed at a much earlier period than the cotyledons. The difference of cotyledons is repeated in the leaves; for example, in *Stapelia*, where the cotyledons are small, the leaves are also rudimentary, and in *Cuscuta* the absence of cotyledons points out the subsequent leafless habit of the plant.

*Of the disc and nectary.*—The term nectary was used by Linnæus and his disciples for divers glands, tubercles, appendages, or fleshy swellings found in flowers; the moderns have reduced the term nectary to glands, which secrete a sweet liquid in flowers, from which bees extract honey, and is always in the centre of the corolla. The position of nectaries is upon the torus, and forms in the *Calyciflora* a disk on the top of the ovarium. There is a great abundance of nectar in the bottom of the corolla in *Cobœa*, *Campanula*, &c., upon the torus in *Crassulaceæ*, *Araliaceæ*, &c. When the flowers are regular, the nectaries are placed symmetrically in relation to other organs, as for example, as they may be considered a row of stamens or carpels; in that case they are in the form of fleshy tubercles and sometimes hard tubercles, always smaller than the filaments. In irregular flowers they are placed in the bottom of the spur, or near the place where the spur should be when that organ is wanting. They are found upon the ovarium in the Hyacinth and upon the anthers in *Adenanthera*, and upon the corollas or calyxes in divers plants. Very often nectaries hold the place of stamens or other abortive organs, as may be seen in all unisexual flowers; therefore when they are present it is presumed that some organ or organs are abortive or not developed.

*Of æstivation, or the arrangement of the parts in the unexpanded flower.*—Æstivation is a term used for the relative position of the floral parts in the same verticil or row, and is analogous to the vernation in leaves. The irregularity of some flowers renders their æstivation complicated and strange, but in regular flowers it is distinguished in the following manner: 1. the æstivation is said to be valvate, in which the parts or lobes of the same verticil touch each other on both edges without overlapping in any way; examples, the sepals of *Clematis*, *Malvaceæ*, the petals of the Vine, &c.: 2. induplicate, where the edges of the parts are recurved a little inside: 3. reduplicate, where the edges of the parts are curved outwardly, as in the petals of *Umbelliferæ*: 4. twisted, where each piece of the same verticil curves in one direction, as the corollas of *Malvaceæ*, *Apocyneæ*: 5. quincuncial, where there are five parts placed three on the outside and two inside, and *vice versâ*, as in the calyx of *Cistus*, *Rosa*, &c.; this kind of æstivation is often called imbricated, but it must not be confounded with the true imbricate æstivation; it is supposed to be formed from two verticils. When the corolla or calyx is formed of several verticils the æstivation is called, firstly, alternate, when the pieces of different verticils alternate with each other, as in the petals of *Nymphæa*: secondly, imbricate, when the pieces of different verticils are laid upon each other, in the manner of tiles upon the roof of a house: thirdly, opposite; this kind of æstivation is very rare, where the pieces of two verticils are exactly one in front of the other, as in *Epimedium* and *Leontice*. The petals, stamens, or carpels, as seen in the bud, are sometimes straight and sometimes rolled inwards, in which case the æstivation is said to be involute; sometimes recurved inwards, it is then called replicate, and if rolled inwards, it is said to be circinnate; and sometimes it is turned all to one side in a spiral manner. These organs cross principally by the base in such a manner as that the lobes of a polypetalous corolla appear to be joined into a tube.

*Of the adherence and concretion of the parts of the flower.*—Sepals are frequently joined together as well as the petals and stamens, even although disposed in many concentric verticils, and the same with neighbouring organs of a different nature, as the sepals with the petals, the petals with the stamens, the stamens with the carpels; and, finally, many of these organs at one time. In the class *Thalamifloræ* all the verticils of different natures are distinct from their base, such as sepals, petals, stamens, and carpels. The torus in this class offers different forms, which appear the most elevated part of the flower; so that in Ranunculus and Magnolia, &c. the torus is conical towards the

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centre and bears the carpels as well as the other organs. In *Anonaceæ* the torus is usually of this conical form, or it is concave in the centre, but swelled under the stamens in such a manner as to render them more elevated than the petals, whilst the carpels are sunk in the cavity. Nevertheless, in all these cases the torus is always distinct and the organs placed upon it, which are separate from each other. It is the same in *Capparideæ*, where the base of the carpels is surrounded by a prolongation of the torus in the form of a ring. In other cases it is sometimes difficult to decide where the insertion of the organs commence upon the torus, as for example, they are not clearly articulated to it, for it is almost impossible sometimes to say whether the fruit is surrounded by a prolongation of the torus, or the combined bases of the stamens. This anomaly may be seen in *Nymphæaceæ* and in *Pæonia Moutan*. Notwithstanding all plants are placed in the class *Thalamifloræ*, where the stamens are manifestly inserted under the ovaries, and which insertion is called hypogynous, or the ovarium is said to be superior, and the calyx, &c. inferior. In the next great class, called *Calycifloræ*, the petals and stamens appear as if borne upon the calyx, but whether the bases of these organs are joined with the calyx or torus in part, or give birth to them, is not known, but the stamens and petals are always found adherent or inserted in the calyx; but the last explanation is the most natural, as there can be traced the bases of these organs inside the tube of the calyx. When stamens are joined with or adhere to the tube of the corolla, the course of the filaments can always be followed inside the tube. The stamens and petals in *Calycifloræ* are borne at more or less elevation upon the calyx, as this adhesion is more or less prolonged; this kind of insertion is called perigynous, or the ovarium is said to be inferior. The torus is therefore prolonged between the carpels and the calyx, and is equally combined with both these organs; such at least is conceived to be the organization of flowers where the ovarium is adherent to the calyx, and what is termed by botanists ovarium adherent or calyx adherent, or ovarium inferior and calyx superior; while on the contrary, if this adhesion does not take place, the ovarium is said to be superior and the calyx inferior, in opposition to the first. In plants where the ovarium is inferior or adherent to the calyx, there is frequently seen on the top of the ovarium a disk analogous to the torus in *Thalamifloræ*, upon the edge of which the stamens and petals are borne. The analogy in the consistence, colour, and nature of this superior disk with the true torus, confirms the idea that the adherence of the ovarium with the calyx is occasioned by the prolongation of the torus between them, and not by the interposition of the simpler bases of the stamens and petals. When the ovarium is quite adherent to the calyx and the stamens at the top of the ovarium, the insertion is termed epigynous, as in *Umbelliferæ*. The *Corollifloræ* is another great class of dicotyledons where the stamens are simply joined by their filaments to the corolla, which is always gamopetalous or monopetalous; as for example, *Datura*, *Convolvulus*, *Cobæa*, *Labiatæ*, *Primula*, &c. In general, the adherence of floral organs explains all the differences of organization, however odd, as has been already mentioned.

*Absence or non-developement of certain parts of the flower.*—All organs are subject to incomplete developement in the same manner as if they were not developed at all; and this abortion is the cause of the want of symmetry in flowers: as for instance, many plants which have a determinate number of carpels, that from the moment the flower opens probably preserves but one of these carpels during the maturation of the fruit; that is, if an ovarium having three cells at the moment the flower opens preserves but two or even one of these cells, the partitions of the abortive cells join with the neighbouring partition; this abortion is probably caused in the bud or at the period of the first developement of the organs, when they are beyond our means of observation. Premature abortions are sometimes evident, as may be seen in many *Corollifloræ*, where the calyx is generally of five lobes, the corolla of five lobes alternating with those of the calyx, and the stamens five in number alternating with the lobes of the corolla; where sometimes four stamens are situated between four of the lobes of the corolla, and in the place of the fifth stamen there is a small filament without anther, or a badly formed one, or a small gland, and sometimes nothing at all. The calyx is rarely wanting, and in cases where it is supposed to be absent is always extremely doubtful; in *Nemopanthes*, for example, the tube is often found to be reduced to a thin membrane, and the limb to hairs or teeth, &c., as in *Compositæ*; in *Umbelliferæ* the lobes of the calyx are often wanting. The petals in some *Capparideæ* are completely abortive, and in some *Caryophylleæ*, as in *Sagina* and *Mollugo*, and in many other plants. The absence of stamens and pistils is more remarkable, because of the importance of these organs. In the same species and upon the same plant one or other of these organs is imperfectly developed, or for example, the stamens are deprived of pollen, or ovaria of ovules; and sometimes one or other of these organs are absent altogether. This is constantly the case in flowers called unisexual, in opposition to hermaphrodite or bisexual, where both these kinds of organs are completely developed. In the *Monochlamydeæ*, another large class of dicotyledonous vegetables have only one envelope to the flower, but whether a calyx or corolla is not known, and is therefore called a perianth or perigone; its nature is uncertain; it is single in certain dicotyledons, as *Daphe*; double in monocotyledons, as *Liliaceæ*; it is either in separate pieces or joined in one piece. Tournefort regarded it as a calyx when persistent, but as a corolla when caducous; and Linnæus called it a calyx when green, and a corolla when of any other colour; denominations not at all philosophical, as there are often found a caducous or coloured calyx, and a persistent or green corolla. M. Jussieu regarded the perigone as a calyx, as petals are more often absent than sepals. M. De Candolle remarks that the perianth of the Great Nightshade and many other monochlamydeous flowers resemble leaves outside by its green colour, hairs, glands, and stomata, &c., and the inside petals by its varied colours and absence of stomata, &c.: he suspects, therefore, that the perigone is double, and that the petaloid membrane inside is a prolongation of the torus, similar to a disk in *Calycifloræ*. In *Liliaceæ*, *Irideæ*, *Amaryllideæ*, &c. the perigone is divided into six parts disposed in two verticils, alternating with each other, and the three inner may be regarded as the corolla, and the three outer as the calyx; in these cases the perianth is said to be double, in opposition to those that are composed of a single verticil and are called single. Perhaps it might be as well, in flowers with a single perianth, to consider it as a calyx when the stamens are opposite its parts or lobes, and a corolla when they

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are alternate with its lobes. The ovarium may be either free or combined with the perianth; it is therefore both inferior or superior in monochlamydeous plants.

*Of the flowers of grasses.*—The special form of the floral organs and singular inflorescence deserves to be separately noticed, as the terms used to designate the parts are different from those used in the descriptions of other plants. What is generally considered the ear in grasses is the reunion of small lateral ears called spikelets or locustæ, surrounding an indefinite central axis called the rachis. At the base of every spikelet are two opposite concave scale-like bracteas which are called the glumes, and above them are one or many alternate sessile flowers called florets; each of these are enveloped by two scale-like bracteas, of which the outer one is generally prolonged into a point called the arista or awn, and the other one, which is situated on the opposite side of the rachis and a little higher up, is bifid, composed of two pieces united by a transparent membrane, and is called the glume by most authors, but by Linnæus the corolla, by Jussieu the calyx, by R. Brown the perianth, &c.; and within the glume and opposite it are two very small fleshy scales called glumellules, by Linnæus called the nectary, by Jussieu scales or squamulæ; they are regarded as representing the perigone in other monocotyledons. The three stamens and the ovarium are borne within these scales. Several families, such as Palms, Rushes, and *Cyperaceæ*, serve by comparison to explain this singular structure, that spaths in Palms, or bracteas or scales in Grasses, usurp in appearance the place of ordinary floral envelopes.

*Multiplication of the parts of a flower.*—If the parts of a flower cannot be developed but in certain cases, it is evident on the contrary that they multiply under favourable circumstances. There are two kinds of multiplication of floral organs; for instance, the number of verticils may be increased, or the number of pieces of every verticil may be augmented. These multiplications take place by accident, nevertheless, in a permanent manner in certain varieties which are prized, and therefore preserved and propagated by other means than by seeds, as by offsets, slips, buds, and grafts, &c. In the Clove Pink, Carnation, &c., in which the bracteas are multiplied in great number by cross pairs in place of one; *Datura fastuosa* frequently presents corollas multiplied one inside of another. In flowers containing a number of stamens, the number of verticils are more or less numerous, and it is the same in the case of carpels where they are numerous. This kind of phenomenon alters the natural symmetry of flowers, for in a flower with five petals, and five stamens alternating with the petals, the range or relative position of the parts are altered. While it must be remarked that the supernumerary verticils of petals, stamens, or carpels always alternate with that which precedes it from the outside of the flower. The multiplication of parts of the same verticil, and sometimes by chance of many of the verticils in the same flower, so that in a plant bearing flowers of five sepals and five petals, &c. may be found a flower of six petals and six sepals; and sometimes organs which ought to be isolated are transformed into a heap of analogous organs, that in place of every petal there is a bundle of petals. Probably flowers where the number of floral verticils are numerous or composed of a number of parts, ought to explain this by their disposition to multiply these organs, as in the plants whose flowers are naturally double, as *Nymphæa*, *Pæonia*, *Malva*, &c., where the number of verticils is always considerable. Flowers become double either by the multiplication or by the transformation of verticils; in the latter case it is certain organs are transformed into petals, as we sometimes see flowers, which ought to have five stamens and five alternate petals, have ten petals placed in two alternate verticils, it is therefore clear that the stamens have become petals. The double Columbine presents two sorts of transformation; the variety called stellata is occasioned by the transformation of the filaments into petals, and the other, called corniculata, is produced by the anthers being changed into horns.

*Morphology, or the transmutation of organs.*—The celebrated poet Goethe was one of the first who observed the transformation of floral organs, and applied to it the term metamorphoses of flowers. The parts of a flower furthest removed, or more distant by position, have least of the nature of leaves, for we find that sepals are more analogous to leaves than petals, and petals than stamens, &c. In double flowers the stamens become similar to petals, and carpels are often changed into stamens; in some cases all these changes take place at the same time, as by accident all the parts of a flower are transformed into flattened green leaves, similar to the true leaves of branches; this is often the case in *Companula rapunculoides*, more rarely in *Rosa* and *Iris*. On the other hand there are examples of bracteas and sepals changing into petals, or the appearance of petals. Petals changed into stamens have been seen accidentally in Shepherd's Purse, and in *Magnolia fuscata* of petals transformed into carpels. There are two species of metamorphoses which go on in an inverted sense. Goethe regarded the flower as an organ more perfect than the leaves, and called it the first kind of transformation or descending metamorphosis, and the second the ascending metamorphosis. These metamorphoses, as well as degeneracies, abortions, unions, and multiplications of organs, are either accidental or natural in each species, probably owing to causes connected with the special developement of the individual or to the primitive disposition of organization of the species.

*Fruit, or mature ovarium.*—Very soon after the expansion of the flower and the fall of the pollen upon the stigmas, the floral organs change their aspect; the stamens and corolla fall or become dry, the calyx is detached, or it becomes enlarged and persistent, the stigmas in most cases disappear, but the ovaria increase in size and become the fruit, and the ovula change into seeds. The term fruit is intended to designate not only the carpels at maturity, but the carpels with the envelopes, which often adhere to them. The study of the fruit altogether is called Carpology, a study of great importance, as the fruit is the result of all vegetation, and the seeds are the mysterious means by which species are reproduced.

*Of simple fruits or apocarps.*—A carpel is considered the same as a leaf folded upon its edges, and is composed of three parts, the surface or outer membrane called the epicarp, the inner membrane called the endocarp, and the substance between these two membranes called the mesocarp, the whole forming what is called the pericarp. The epicarp is the same as the lower surface or epidermis of leaves, and like it often bears hairs, glands, and stomata. It rises readily in the form of a transparent pellicle in Peas, Beans; it is

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readily detached in the Peach, while it adheres to the mesocarp in the Apricot: the endocarp, on the contrary, represents the upper surface of the leaf, and varies much in its nature, consistence, and colour, &c. In the legumes of Peas, Beans, &c. it is thin, transparent, or green, like the epicarp. In Almonds it forms what is commonly denominated the shell. In the Peach, the Apricot, and the Cherry, it is the bony part of the nut. There are also cartilaginous endocarps. The epicarp is seldom furnished with stomata, in consequence of its situation inside the fruit. The mesocarp is the same as the mesophylla of leaves; it is either thin, thick, fleshy, or fibry. In the Almond it is the dry or fibrous part which surrounds the nut. In the Peach, the Apricot, and the Cherry it is the fleshy part of the fruit. The name sarcocarp, given by some authors to the mesocarp, is not so good, as it cannot be applied so generally. In many *Fumariaceæ*, as in *Cysticapnos*, the mesocarp is puffed up, full of empty spaces, and traversed irregularly by fibres which unite both surfaces. The mesocarp is often an elastic, hardened, or dried membrane. The adhesion or junction of the edges of the carpellary leaf forms the ventral suture, as in *Leguminosæ*, Peach, &c.; for that it is opposed to the back of carpel, where the seeds are borne on both sides of the primary nerve. When the primary or dorsal nerve of a carpel is opposed to the seminiferous suture, it frequently resembles it. Carpels may either be dehiscent or indehiscent; that is to say, they may open or remain closed at maturity. The dehiscence may either take place longitudinally or transversely, but the latter is the rarer mode. It may either open by the ventral suture or by the dorsal nerve, as they are both natural lines of dehiscence. However, the carpel may be so firmly joined at these lines that a rupture sometimes take place on both sides, as in *Hæmatoxylon* or Logwood, a leguminous plant. The pieces which detach themselves naturally from each other are called the valves. If a pericarp is intimately combined with a single seed it is necessarily indehiscent. Seeds, when borne on the ventral suture, and only one or two in each carpel are developed, they are either fixed at the base or summit of the carpel, and constantly either hang or stand erect. If a seed is supported by a funicle, umbilical cord, or pedosperm, which usually takes the form of a small, short thread, the point in which the funicle or thread is attached to the carpel is called the placenta. In *Leguminosæ*, as Peas, Beans, &c., and many other fruits, the funicles are more remarkable than the placenta, although the placenta is often very large, fleshy, and fills a large portion of a carpel. The placenta can only be regarded as a peculiar swelling of the edges of carpellary leaves, or the effect of the combination of a great number of funicles. Carpels may either be solitary, as in *Leguminosæ*, or numerous in the same flower, as in *Ranunculaceæ*, *Rosaceæ*, &c. The assemblage of carpels gives the fruit various appearances. In *Geraniaceæ* they surround a solid axis; in Butter-cups and Strawberries they are seated on an elevated more or less fleshy torus; in Roses, in the bottom of a concave torus, which is combined with the calyx. Every species of carpel may be conceived dry, fleshy, dehiscent, or indehiscent, and placed upon a torus or axis of different natures.

*Of compound fruits or syncarps.*—The various combinations of carpels constitute what are called compound fruits or syncarps. When this is the case they also usually adhere to the calyx by the intervention of the torus. The junction between the carpels forms the cells, when the edges are bent inwards to the centre of the fruit. The partitions so formed are therefore composed of the two lateral membranes of the carpels together. The placentas rise from the inner angle of every carpel, as in *Nigella*, Mallow, &c. But when the edges of carpels do not reach the centre of the fruit, there exist a single cavity, having the placentas upon the circumference, as in Violets and Mignonette, which are therefore called parietal placentas. The partitions of the cells are sometimes very short, and become obliterated or destroyed during the maturation of the fruit, while there remains a large placenta in the centre, accruing from the agglomeration of all the placentas of the cells, and is therefore called a central placenta, for it is only by the examination of very young ovaria that its connection or communication with the rest of the fruit can be seen; as for example, in *Caryophylleæ*, *Portulaceæ*. Compound fruits either do not open, or open by two principal modes; the septicidal and the loculicidal. The first when the carpels disunite at a certain era and separate, as for example, in Rue and Colchicum. The second is more common, and is occasioned by a longitudinal rupture along the back of each carpel or cell, and consequently by the primary nerve of the carpellary leaf; the partitions are therefore not disunited, being formed from the ventral suture, and are borne along the middle of the valves; when this mode takes place the valves are said to be septiferous in the middle. There are a great many other modifications of dehiscence which are more or less analogous with these two, as for instance, a fruit opens sometimes at the upper extremity only by pores, as in *Linaria*, or by valves, as in *Erica*. The valves sometimes separate from the base to the top, as in *Eschscholtzia* and *Cruciferæ*. When the placenta is central the dehiscence sometimes takes place at the tops of the valves, as in Pinks, Carnotions, Catchfly, &c.; or by a rupture of the circumference, as in Anagallis, Purslain: this manner is termed transverse, transversal, or circumscisse. When compound fruits are combined with the calyx, the drying of the membranes equally occasions them to burst in most cases. Commonly the dehiscence takes place above the tube of the calyx, when the ovarium is free; but often also the tube of the calyx is split in different ways, as in *Umbelliferæ* it divides in two, and each of the carpels bears its own part of the calyx. In *Campanulas* and *Anterrhineæ* there are frequently valves or holes of dehiscence upon the side of the tube of the calyx. The carpels of a compound fruit, like that of a simple fruit, may be either fleshy, dry, or bony. The epicarp, mesocarp, and endocarp may also be of divers consistence. The number of combined carpels vary; sometimes many of them are abortive; and often in the same flower they are found to be reduced to a single carpel, as is seen in all *Leguminosæ*, causing the eccentric position of that carpel by the abortion of the others. When there is only one cell where there are two styles and two stigmas, as in *Compositæ*, *Gramineæ*, and some *Euphorbiaceæ*, it ought always to be presumed that the so-called styles are only sessile stigmas.

*Of fruits issuing from many flowers, or polyanthocarps.*—Fruits which issue from different flowers, and are combined or joined into one, or even approach each other, are said to be aggregate. The cone in the Pine is evidently the reunion of many fruits, for every scale appertains to a separate flower. In *Dorstenia* many small flowers are placed upon a concave recep-



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tacle: in the Fig the receptacle is so concave as completely to hide the flowers, and afterwards the fruit. The Pine-Apple, Breadfruit, the African-Peach, are truly aggregate, although each carpel springs from a different flower. Altogether it is nothing more than a reunion of carpels, perigones, bracteas, and the floral axis into one fleshy mass, which appears like a single fruit. In many Honeysuckles the flowers approach by twos, and the fleshy fruit of both are combined by their inner sides.

*Of spurious fruits, or pseudocarps.*—In *Pollichia* the bracteas are fleshy, and therefore resemble fruit. In Cashew-nut, the fruit commonly called the nut is a coriaceous carpel at the extremity of a fleshy, thick peduncle, resembling a Pear, and which is ordinarily called the fruit. In *Hovenia*, *Exocarpus*, *Podocarpus*, &c. the same occurs.

*Of the classification of fruits.*—As has been shown in the preceding articles, there are three distinct classes of fruits, simple, compound, and aggregate, besides spurious fruits; to characterise the different modifications of these botanists have applied a mass of useless terms, which only encumber the science; for to pretend to give terms to all the modifications would be folly. The following is the principal forms of the fruit, and all that deserve to have terms applied. It is of vast importance to bear in mind whether the carpels are free or joined together, free from or combined with other organs, dehiscent or indehiscent, fleshy or membranous, solitary or many together, &c.

*Forms of apocarps or simple fruits.*—1. A follicle is a carpel which opens longitudinally by the ventral suture, the pericarp not being fleshy, but usually foliaceous. There are generally many follicles to the same flower: examples, *Delphinium*, *Pæonia*, *Banksia*. 2. A legume is a single carpel opening lengthwise by two valves, both by the ventral suture and dorsal nerve at the same time, being a little or not at all fleshy, &c.: examples, *Leguminosæ*, as Peas, Acacias. 3. A loment is a legume which is contracted between the seeds, or the endocarp of both valves are joined by their inner surfaces, and therefore does not open like a common legume, but separates or breaks transversely, every joint containing a single seed: example, *Ornithopus*. 4. A drupe is an indehiscent fruit in which the mesocarp is fleshy, and the endocarp coriaceous or bony; there is usually only a single carpel to each flower, with few seeds. The mesocarp is sometimes of a fibrous nature: examples, Peach, Apricot, Almond, Cherry, Plum. The fruit of the Raspberry, Bramble, Cloudberry, are but small drupes accumulated in great numbers upon a convex torus. 5. A nut is an indehiscent, bony carpel, generally small, containing a single seed, which is not joined with the pericarp: example, *Boragineæ*. The Strawberry is an accumulation of little nuts upon a fleshy, convex torus; and the fruit of Roses is a similar accumulation of nuts on the inside of the torus, which is combined with the tube of the calyx, which becomes fleshy, and is named by some botanists a cynorhodon. 6. An utricle is a membranous, elastic pericarp, breaking sometimes in a transverse manner by the base rather than by natural dehiscence: example, *Amaranthus*.

*Forms of syncarps or compound fruits.*—A. Those not combined with the calyx or perianth by the intervention of the torus, and are indehiscent, are as follows. 1. A cariopsis is a pericarp of one cell by abortion, terminated by two or three stigmas, and joined or combined with a single seed, as in grasses. 2. A samara has cells jutting outwardly under the form of dorsal wings, without flesh or pulp, as Maples and Ashes. 3. An amphisarc has a pericarp which is not fleshy, but rather hard, and with pulp surrounding the seeds in the cells, as *Crescentia* and *Adansonia*. 4. A naculanium has a fleshy mesocarp and also pulp in the cells; it is a berry not adhering to the calyx, and is a term hardly in use; it is commonly called a berry, as if it adhered to the calyx: example, Grapes. 5. A *Hesperidium* or Orange is a fruit whose epicarp is united outside so as to hide the junction of the carpels, and bearing a multitude of thick, lymphatic hairs on the inside of the endocarp, which are filled with liquid, and form by their proximity a kind of pulp. The carpels, after the epicarp is taken off, are readily separated, when it is seen that it adheres but little to the rest of the pericarp. The cells appear to be formed from a prolongation of the endocarp, as the Orange, Lemon, and Citron. B. Those not combined with the calyx or perigone by the intervention of the torus, and are dehiscent. 1. A conceptacle or double follicle is composed of two follicles joined together by the back, as in *Asclepiadeæ*, and in most *Apocyneæ*. 2. A silique is formed of two carpels joined together their whole length into a dry, two-valved fruit, with a thin, transparent partition, which is probably formed by the fine drawn epicarp. The seeds are attached to both edges of the partition in each cell; the valves separate from the base to the apex, as in most *Cruciferæ*. When this kind of fruit is short it is then termed a silicle. 3. A capsule is composed of two or more carpels combined into a single, dry fruit, with any kind of dehiscence, as Rue, Pink, Rhododendron, Digitalis. The term capsule includes all dry fruits composed of two or more pieces, but may be often one-celled by the abortion of the partitions. 4. Pyxidium is a capsule with a central placenta opening transversely, and in descriptions is called capsule circumscissed, as Anagallis, Purslain, Primula. C. Those adhering with the calyx or the perianth by the intervention of the torus, and are not fleshy. 1. A diplostegia or adherent capsule is a capsule adhering with the calyx, composed of two or more carpels, and may be of one or more cells, as Campanula. 2. A eremocarp is two or more one-seeded, indehiscent carpels, joined with the tube of the calyx, each having a single seed inside, and at a certain era the carpels called mericarps separate from the base to the apex, splitting the tube of the calyx, each carpel or mericarp bearing on its back its portion of calyx. This kind of fruit is also called a diakene, pentakene, polyakene, according to the number of akenia or carpels which compose it. 3. An akenium is an indehiscent carpel, left solitary by the abortion of others; it is joined with the calyx, and contains a single seed. The calyx being usually terminated by a plume or pappus composed of hairs which represent its lobes, as in most of the *Compositæ*. 4. A gland or acorn is a coriaceous or woody, indehiscent pericarp, joined with the perianth; it is one-celled by abortion, and contains one or more seeds, surrounded at the base by a cupula or cup, to which it does not adhere, and which is originally an involucrum to many flowers, all of which have become abortive except one, as the Oak, Filbert, Sweet Chestnut, Hazel-nut, &c. D. Those which adhere with the calyx or perianth by the intervention of the torus, and are fleshy. 1. A pome is composed of many indehiscent

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carpels in a whorl, with a cartilaginous or bony pericarp, completely enveloped by a fleshy, indehiscent calyx, which is combined with them. The lobes of the calyx and remaining stamens are seen on its top, which is commonly called the eye of the fruit. The flesh of the calyx is the edible part of the Apple, Pear, Quince, Medlar, Hawthorn, &c. There are two seeds in each carpel, placed side by side. 2. A melon or pepo is composed of many indehiscent carpels in a whorl not splitting at the edges, forming a unilocular, fleshy fruit, with parietal placentas and numerous seeds, which are imbedded in pulp, as the Melon, Cucumber, Gourd, &c. 3. A berry is a many-celled fruit, with a half-liquid, indehiscent calyx and pericarp. The seeds are surrounded by pulp, and are readily separated at their point of attachment, as the Gooseberry, Currant, &c. The term berry is used for every half-watery or pulpy indehiscent fruit, in opposition to the term capsule, but it is more proper to retain this term for pulpy fruit with which the calyx is adherent. 4. A balausta or pomegranate is a many-celled, indehiscent fruit, adherent to the calyx with a hard envelope, and seeds surrounded by pulp, without losing their attachment. The fruit is composed of a double verticil of cells one verticil above another. The term is seldom used: example, Pomegranate.

*Forms of polyanthocarps or aggregate fruits, or those formed by the proximity or junction of many flowers.*—1. The combined or joined berry, as *Lonicera*. 2. A cone is an assemblage of sessile fruits, each composed of a pericarp in form of a convex scale, and of a seed which is situated at the base of the pericarp, as the genus *Pinus*, &c. The scales are combined in some cones, as in the Juniper. By some botanists these are called gymnosperms. 3. A sycon is a fleshy, concave receptacle surrounding the fruits more or less, which are numerous, small, and distinct, and therefore issue from a great number of flowers. At maturity this receptacle has a tendency to spread out. The term is not much used: examples, the Fig, Dorstenia, &c. 4. A sorosis is when the carpels of many flowers are combined or joined by the intervention of the floral envelopes, the bracteas, and floral axis being fleshy, adhere together. It is a term seldom used: examples, Pine-Apple, Bread-Fruit, Jack-Fruit, &c.

*Of the seeds at maturity.*—When the increase of an ovulum is terminated it is called a seed. It may be considered as composed of three parts, of which two exist in every case, the spermaderm, or testa, and embryo.

*Of the spermaderm or testa.*—The seed is regarded as enveloped in either two or three coatings or membranes, each of which has a separate term applied: the outer or surface coat is called the testa or outer membrane, the other the inner membrane; to this Richard has applied the term episperm or perisperm. De Candolle has, however, applied the term spermaderm to all the coatings of the seed, to the outer one testa, and to the inner one endopleura; and between these two coatings there is a substance which he calls the mesosperm, considering the spermaderm analogous to a leaf. Ovules are formed of crossings of the edges of leaves, and not metamorphosed leaves, as the carpels, petals, &c. The testa of seeds is usually coriaceous, and of a brown and shining colour, analogous to the surface of shells, hence the term. This portion of the spermaderm readily absorbs liquids. In some plants the testa is rough to the touch from small asperities; sometimes it bears hairs at one extremity or other, or at both, which is called a coma or tuft of hairs; in the cotton the whole surface is covered. That part of the seed by which it is attached to the funicle, and where there is always a mark, is called the hilum, or umbilicus, or cicatricle. In the Sweet Chestnut the testa is smooth and shining, and the hilum is white, and occupies a considerable space; the centre of the hilum through which the nourishing vessels pass from the placenta to the ovule is very peculiar, and has been named by Turpin the omphalobium, or navel of the seed. The inner membrane, which in most cases is the secundine of the ovule, is not shining, and does not readily absorb liquids; at its base is what is called the chalaza or internal umbilicus, and from which springs the raphe that unites the hilum with the chalaza. The openings or foramens, called the endostome, and exostome in ovula, are almost closed up in mature seeds. In consequence of the unequal manner in which the membranes of most seeds are developed, these foramens, called micropyle by Turpin, often touch or adjoin the hilum.

*Of the albumen.*—The albumen is an intermediate substance which frequently exists between the embryo and the spermaderm: it is either fleshy, farinaceous, oily, or corneous. Several authors call it the perisperm, from its surrounding the embryo; it is called albumen from its colour, being naturally white, as well as from its being likened to the white of eggs. The albumen is at first watery, afterwards milky, and finally of the proper substance. It was for a long time regarded as a single homogeneous body, but Dr. R. Brown shows that in *Nymphæaceæ* and *Piperaceæ* it has a deposit in the embryonary sac, and another in the cavity which contains the sac, which is the result of two joined albumens. It appears that the embryo absorbs all or part of the liquid which forms the albumen, for the larger the embryo the less the albumen; for in seeds without albumen the embryo is very large in comparison to the size of the seed, as in *Cruciferæ*, *Leguminosæ*; and on the contrary, if the albumen is large the embryo is small, as in most *Monocotyledones*, *Convolvulaceæ*, &c. The albumen of many plants, particularly grasses, is the fecula or farina; while that of many Palms and *Euphorbiaceæ* is oily. In Ricinus the oil of the albumen is called castor-oil. The horny or corneous albumen, as in Coffee, &c. give out an agreeable odour on being burnt, and unite the taste with the perfume.

*Of the embryo.*—The embryo is the young plant protected by all the envelopes which we have already mentioned. The suspending thread which unites it to the ovulum, and which is probably nothing but the extremity of the radicle, which quickly disappears and is never seen in seeds which approach to maturity. The radicle or the young root, the plumule or the young stem, and the cotyledons or the first leaves, constitute the embryo. The radicle is always directed towards the endostome in such a manner that in orthotropous seeds the embryo is superior or inverted, that is to say, pendent, while in anatropous or campulitropous seeds, which are the most numerous, the embryo is inferior or erect, that is to say, the embryo is next the hilum; the *Cistineæ*, *Urticeæ*, &c. have a superior embryo, for in almost all other plants it is inferior. Sometimes the inner parts are a little recurved in such a way that the embryo is transverse in relation to the hilum, as may be seen in *Myrsineaceæ* and *Primulaceæ*. All these positions of the



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embryo ought to be examined, as well as the position of the seed in the fruit, and of the fruit upon the plant. It so happens that if the seed is pendent in the fruit, that the embryo is pendent in the seed; but if the seed be erect in relation to the fruit, or probably to the horizon, it follows that the embryo is erect. When the embryo occupies the axis of the seed it is said to be axil, and when it is in this central position and very short and inferior, it is said to be basilar; if very short and superior it is called apicular. Sometimes it is curved, being longer than the seed, it is then said to be peripheric; and when it is rolled back upon itself it is called spiral; it is often straight, curved in various ways, independently of all considerations of the neighbouring organs.

*Of the radicle.*—The radicle or first root is generally short and pointed, sometimes thick and obtuse; its length varying in different species. When seed is placed under favourable circumstances the radicle swells and lengthens in various ways; in most dicotyledons the increase takes place at the extremity of the radicle without any rupture of the tissue of that extremity; while in the monocotyledons and some dicotyledons it bursts through a peculiar kind of sheath, called the coleorhiza, from which the root protrudes. Richard named the roots of the first exorhizes, and those of the second endorhizes. The part of the radicle nearest the stem or cotyledons is furnished during germination with small, lymphatic, simple hairs, which are not long in falling off, and are called the hairs of the radicle, and probably act as rootlets. The radicle has always a tendency to descent during germination.

*Of the plumule.*—The young stem is often hardly visible even in the seed, and in other cases it is as long as the radicle. It is composed of two parts; the one under the cotyledons is called cauliele, and the other above the gemmule.

*Of cotyledons.*—The cotyledons are the first leaves or the lateral membranes of the embryo. They are usually furnished with stomata, vessels, and glands, &c. like the leaves, but they are wanting in the embryos of leafless plants, as in *Cuscuta*, and sometimes have small axillary buds. Their form when present is roundish, less divided or toothed than the proper leaves, and their nerves are less prominent. The two great classes of phænogamous plants are characterised by their cotyledons; those furnished with two cotyledons are called dicotyledons; and those with one monocotyledons. Besides the number, these two classes may be readily known by the position of the cotyledons; in the first they are opposite, in the second they are never so. The single cotyledon of the last class embraces the gemmule in the same manner which the subsequent leaves ordinarily surround the stem. Cotyledons in the first class are often joined together, as in the Horse Chestnut, Monkhood, &c.; there is generally a mark to show where the two cotyledons are joined, and at which point they disunite at some point or other although very slowly. The inequality of cotyledons is found in an extreme degree in *Trapa*, where one of the cotyledons is so short that the young plant resembles a monocotyledon. The absence of cotyledons in *Cuscuta*, &c. and in other dicotyledons indicates a leafless plant. The *Cyclamen*, *Lecythis*, and all the family of *Lentibulariæ* offer anomalous germination without cotyledons. In *Ceratophyllum* and some coniferous plants, there appear to be four or more cotyledons in a whorl, but these are better regarded as two cotyledons divided into parts. In the Orange tribe there are commonly found in one seed two or three embryos, and accidentally in other seeds. In some instances two embryos may be joined together having four cotyledons and two gemmules. Cotyledons, as seen in the seed, are generally flat, and two in number, applied to each other face to face. In some *Aurantiaceæ* the cotyledons are widened at the base, and recurve mutually upon the edges. Besides flat cotyledons there are plicate cotyledons; these are plaited either once or twice transversely or longitudinally upon their middle nerve, or rolled, as in *Cruciferæ*; spiral, as in *Combretum*; and finally, they may be irregularly rumpled, as in the Poppy. When the embryo is curved once or twice the relative position of the cotyledons with the radicle should be carefully remarked. The cotyledons are said to be accumbent when the radicle is found at the side of the fissure between the cotyledons, which is the result of their juxtaposition; on the contrary, the cotyledons are said to be incumbent when the radicle lies upon the back of the cotyledons. Foliaceous or thin cotyledons are furnished with stomata, but thick, fleshy, or farinaceous cotyledons are without. These last contain a deposit of nutritive matter which preserves the young plant and is turned to the use of man and beast, as those of Beans, Peas, Lentils, and other pulse.



*Accessory organs of the seed.*—Under this head are included such organs or modifications of organs as are met with only in certain plants, and whose importance as marks of distinction entitle them to a separate notice. 1. The *arillus* is an expansion of the apex of the funiculus, which either partially or entirely envelopes the seed. It is only developed after fecundation has taken place, and is to be regarded as an additional integument of the seed wherever it occurs. The arillus is sometimes fleshy, pulpy, or membranous, and almost always unequal in regard to the sides of the seed. In *Euonymus* it is fleshy and of a beautiful scarlet, nearly investing the entire seed, as is also the case in *Rottlera* and *Bradleia*. In *Myristica* it is large, fleshy, and ramified into a kind of network, forming that singular and beautiful envelope of the seed of the Nutmeg called mace. It is small, and often three-lobed in *Polygaleæ*, and appears under the form of a protuberance in *Violeæ*, and the seeds in this case are termed carunculate. 2. *Vitellus:* this organ is the persistent embryo sac inclosed within the cavity of the albumen, containing the embryo. It is formed by the fifth envelope of the seed, termed by Mirbel the quintine. The vitellus is only apparent in a few plants, as in *Nymphæaceæ*, *Piperaceæ*, *Saurureæ*, *Scitamineæ*. It affords a character of high value, distinguishing families of plants; its presence, or rather visibleness, separates *Nymphæaceæ* from *Nelumboneæ*, and *Scitamineæ* from *Marantaceæ*. 3. *Strophiola* is a fungous enlargement of the apex of the funicle, occurring in the seeds of certain Australian *Leguminosæ*. It is situated near the hilum, and varies in form in different genera. It occurs in *Dillwynia*, *Eutaxia*, *Sclerothamnus*, *Euchilus*, *Pultenæa*, *Daviesia*, and *Gompholobium*. In *Euchilus* and *Pultenæa* it is two-lobed, and in the latter genus the lobes are cut. This organ must not be confounded with the carunculate appendages found at the extremity of some seeds, such as in those of *Tremandreæ*. The strophiola is of the same nature as the arillus, but differs in not inclosing the seed.

*Of the reproduction of vegetables without fecundation.*

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—This kind of reproduction is of two kinds, by division and by the developement of buds. A plant is reproduced by division, as for example, by a slip or cutting, which, if planted in the earth, becomes a new individual by putting forth roots. Certain leaves, as those of *Gloxinia*, when placed in the earth by the petioles or base, have the faculty of emitting roots, and pushing forth buds from the base. Multiplication of individuals by this natural facility by pieces, is not peculiar to vegetables alone, for in animals, as the *Polypes*, each morsel becomes a living individual. New plants propagated in this way are nothing more than the extension of the parents. Buds develope themselves upon many parts of vegetables, particularly in the axils and upon the edges of leaves. Vegetation generally produces a bud in every axil, which is as if it were a new individual upon the parent. Such is the force the juices accumulate at this point, that if you take out a bud of one plant and place it quickly in another it will grow. The eyes of subterraneous stems or branches, as the Potato, by being divided into pieces, each containing one or more eyes, form new plants, like that of a branch above ground. Bulbous plants often multiply by small lateral bulbs which are borne at the base of leaves. The edges of leaves in *Bryophyllum calycinum*, *Malaxis paludosus*, readily produce buds.

*Of the dissemination of seeds.*—At maturity, or a little later, seeds separate from the plant. This function is analogous to the laying of eggs, for plants cannot be compared with viviparous, but with oviparous animals; for the embryo from the parent is enveloped by the spermaderm or albumen. The dissemination of seeds depends upon their form, position, weight, thickness, also upon the form, size, position, dehiscence or indehiscence of the pericarp, also the adherence or nonadherenee of the seed with the pericarp; the form, position, adherence, and divers qualities of the outer organs of the fruit, as the calyx, bracteas, &c., so that every genus, and even every species, offers some modification in the manner in which the seeds are relieved from the fruit. In capsules which open by valves or pores, the seeds issue naturally; in some, as in *Euphorbiaceæ* and *Balsamineæ*, the seeds are thrown out by the elasticity of the valves to considerable distances. The dispersion of seeds in *Apocyneæ*, *Epilobium*, is occasioned by their being furnished with tufts of hairs; and others, like *Bignonia*, by wings on the edges. In indehiscent fruits they either separate themselves by a rupture in the calyx, or by the decay of the flesh and nut, &c. The seeds of most plants fall on the surface of the soil, those of aquatic plants to the bottom of the water, but those of the plants called hypocarpogeous, by their carpels ripening in the earth; in *Cyclamen*, *Morisia*, some *Trifolia*, *Arachis hypogæa*, *Lathyrus amphicarpos*, *Voandzeia*, bear flowers on various points; the peduncles being generally near the base of the plant have the property of becoming recurved during the maturation of the fruit, and forcing it into the earth or into fissures.

*Organization of cryptogamous plants.*—Hitherto we have had principally in view the great class of phænogamous plants in which the organs connected with the functions of nutrition and reproduction are sufficiently distinct. It is now necessary to speak of that great division of the vegetable kingdom which is essentially composed of cellular tissue, being almost wholly destitute of vessels, and in which we can hardly distinguish the organs destined to be the important functions of nutrition and reproduction. This class is composed of vegetables numerous and varied, although for the most part inconspicuous. It is divided into two classes analogous to those of *Dicotyledones* and *Monocotyledones* among the phænogamous plants; the first class consists of thickly cellular plants in which there is no vascularity, and in many of which the sexual apparatus does not appear to exist. The *Musci*, *Hepaticæ*, *Lichenes*, *Algæ*, and *Fungi*, belong to this class, some species of which scarcely present any traces of organization. The second comprise the *Semivasculares*, in most of which vascular tissue (that is spiral and annular vessels and dotted ducts) is found, and frequently stomata, and which are furnished with a distinct reproductive system, approaching to that of phænogamous plants. They have been denominated *Semivasculares*, on account of their structure; by Agardh *Pseudocotyledones*, and by De Candolle *Æthœogamiæ*, the former to denote their analogy to the *Monocotyledones*, and the latter to express that the mode of reproduction is obscure and paradoxical. To this class belong *Characeæ*, *Equisetaceæ*, *Lycopodiaceæ*, *Marsiliaceæ*, and *Filices*; these plants have few general features in common; their organs are so distinct as not to admit of description being given of what the individuals are composed, nor can there be looked for an analogy of organs in the different families composing this class, on account of the extraordinary diversity in their forms. In fact, the external features of these plants are as varied and singular as their internal structure is similar. It has likewise been remarked of the animal kingdom, that the vertebratæ differ less in their external appearance than the *Annulosæ* and *Mollusca*. The extreme diversity which exists in this class among species, genera, and families, and even in the same species at different periods of its existence, renders their study and comparison very difficult. Considered in a general point of view, they may be said to be organized bodies endued with vitality and furnished with reproductive corpuscles. The vegetation of cryptogamic plants presents at first nothing but cellules rounded or elongated into filaments which issue from the reproductive organ. In those families which approximate to the phænogamous class are distinguished a principal root which descends, a compact cellular tissue, lobed or membranous, which expands horizontally, or has even a tendency to ascend. This last part becomes more and more analogous to the ascending axis of phænogamous plants; they are furnished internally with vascular tissue, and externally with stomata. The principal root disappears, but a great number of others are produced which issue forth from all parts of the ascending organs. In some of the thickly cellular class a real axis cannot be distinguished, nor ascending or descending organs. The absorption of water appears in them to take place by the surface of the membranes rather than by roots. So instead of the three fundamental organs of nutrition of phænogamous plants, there are to be found only two in the *Semivasculares*, and only one in the *Cellulares*.

*Root or descending axis in Semivasculares.*—The roots in this class resemble those of phænogamous plants. They originate more readily and indeterminately from all parts of the fronds or stems. Moisture alone seems to determine the elongation of the tissue into roots; they have generally but a very precarious existence. While fresh they absorb humidity, but they quickly dry up, and remain under the form of very slender filaments whose functions have terminated. They are

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constantly being replaced by new roots. These roots, unlike those of phænogamous plants, are organized like hairs, that is, they are composed only of elongated cellules, simple, or collected into bundles. It is probable that these roots absorb humidity by their whole surface, and that they do not elongate and absorb by their extremity only; a circumstance which would distinguish them from the roots of phænogamous plants, especially the *Dicotyledones*.

*Stem, or ascending axis in Semivasculares.*—The whole of the *Semivasculares* have great expansion analogous to leaves, but which nevertheless differ from the leaves in several important characters, and besides these leaflike expansions there is often present an ascending axis resembling a stem. It sometimes appears to give birth to leaves, sometimes, on the contrary, it seems to be formed by the union of the base of the leaflike organs. These two organs are in all cases intimately connected; the foliaceous expansions are never articulated with the axis, but appear to be, on the contrary, a continuation of it. These organs bear the fructification, in which particular they likewise differ from the leaves of phænogamous plants. They may be compared to peduncles more or less dilated or membranous. Botanists avoid applying the names leaves or stems to the organs of the *Semivasculares*, which have the appearance of them. The foliaceous part is designated by the term of frond, and when there is a footstalk analogous to a petiole it is called stipe, and the expanded part the lamina. That part analogous to a stem often takes the name of caudex or rhizoma, on account of its subterraneous position in many Ferns. These organs vary exceedingly in their form. In *Characeæ* and *Equisetaceæ* a continuation of articulations constitutes the axis and its branches. There is nothing like leaves, but the branches are linear and somewhat resemble leaves of Pines. In *Filices* the fronds are attenuated at the base, and unite into a fascicle having the appearance of a stem. These fronds have a midrib with lateral, parallel branches, and their vernation circinnal. This class is distinguished by the presence of vascular tissue, which, however, appears to be entirely wanting in the young state. They are also furnished with a cuticle and stomata. In some of the groups the structure departs from that of Ferns, and becomes more and more simple, and passes into the next class. *Lycopodiaceæ* have annular vessels; *Filices* and *Equisetaceæ* have spiral vessels and dotted ducts. *Characeæ* appear to have no vascular tissue.

*Of Cellulares.*—They consist of a homogeneous expansion, often foliaceous, composed entirely of cellules. Sometimes, as in *Musci* and *Hepaticæ*, there is an axis bearing foliaceous expansions on its sides. In their external form they are more varied than the *Semivasculares*; they are membranous, coriaceous, fleshy, or gelatinous; they either inhabit the water, as the *Algæ*; or grow on rocks or trees, as the *Lichenes*; or parasitical, as many *Fungi*; or grow on the earth, as most of the *Musci* and *Hepaticæ*. Except in these two last families their colour is rarely green, most frequently purple, brown, or grey. Except *Marchantia* none of them possess stomata. Sometimes two layers of cellular tissue may be distinguished, namely, an exterior and an interior one. The roots of *Marchantia*, according to Mirbel, are composed of simple, hollow, conical cellules. When the whole of these organs are membranous, flat, or tubular, they receive the name of thallus, and when branched and expanded like leaves, they are termed fronds.

*Reproductive organs.*—Cryptogamous plants multiply by division, and by reproductive bodies termed spores or sporules, or gongyli. The first mode of increase presents nothing peculiar in cryptogamous plants. The thallus of *Lichenes* may be divided, and the filamentous base of *Fungi* may also in like manner be divided. The joints of the articulated species, such as *Oscillatoria*, *Diatoma*, &c. may be separated. The rhizoma of Ferns may be cut in pieces, each piece becoming a distinct plant. The sporules are produced on the surfaces within certain cellules variously disposed. They frequently resemble minute seeds, but they differ essentially from seeds in having nothing like an embryo within them. On dissecting the largest of these reproductive bodies, such as those of *Chara*, *Equisetum*, there is nothing to be seen but an accumulation of granules enclosed within a common envelope, somewhat like the albumen of seeds, or the cellular matter in the bulbilli and tubercles of phænogamous plants. There is neither aperture nor cicatrix on their surfaces, and from the first period of their developement they appear to be destitute of pedicels. It is therefore probable that they are produced free either in cellules or without them. There are important distinctions between these reproductive bodies and the seeds of phænogamous plants. In the germination of spores one of the sides elongates and sends forth fibres which are at first simple, afterwards becoming branched, which seem to be a continuation of the enclosed cellular tissue. There is nothing analogous to cotyledons to be seen; but the germination of Ferns and the other *Semivasculares* has been compared to that of monocotyledonous plants, from the superior part opposed to the root being solitary. But it is to be remembered that there is this fundamental difference, that the embryo of phænogamous plants is predisposed in the seed at the period of separation or maturity, whilst in the spores of cryptogamous plants there is nothing analogous to be observed. A sporule may be compared to an embryo rather than to a seed. The organs which enclose the sporules vary much in situation and appearance; they are sometimes collected in great numbers in dehiscent capsules, termed theca, sporangia, and sporidia. These organs are commonly stalked, and are either solitary or aggregated; sometimes on the axils of the branches or leaves, as in *Chara*, *Lycopodiaceæ*, and *Musci*; sometimes on the fronds at the extremity of the lateral nerves, as in Ferns; sometimes terminal at the extremity of peculiar peduncles, as in *Equisetaceæ*, which appear to be fronds imperfectly developed. The sporangia are sometimes intermixed with articulated filaments or paraphyses; sometimes they contain elastic filaments, denominated elators, along with the spores; the former appear to be sporangia, and the latter sporules imperfectly developed, and which resemble in appearance large, unrolled, spiral vessels. To these organs and others the functions of stamens, pollen, fovilla, in fact, of male organs, have been attributed; but the diversity of the organs to which so important a function has been assigned clearly demonstrates that the subject is still involved in obscurity, and that the researches of the most acute observers who have devoted themselves to the study of cryptogamous plants have hitherto been unsuccessful in determining the presence or absence of sexual organs. It must be admitted, however, that in *Lichenes*, *Algæ*, and *Fungi*, the spores are less varied in their form, and are surrounded by fewer and less complicated organs, so that it would appear not

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improbable that these are really destitute of a sexual apparatus, whilst the other families of cryptogamous plants are endowed with one. The spores of cryptogamous plants are sometimes naked, or more often enclosed within membranous sacs called asci, which are rarely dehiscent; these reproductive bodies are analogous to the granules commonly contained in the cellules, especially in the pollen; and they separate either by the rupture of their envelope, or by its natural destruction. Turpin regards this mode of reproduction as very general in all classes of vegetables, and has given many curious and instructive examples of it

*Nomenclature.*—The necessity of some universally received name to each plant, and some laws on the subject, has been acknowledged by every botanist, and the Linnæan nomenclature has been adopted by almost every botanist since 1753, that is, that every plant should have two names, a generic and a specific name. As it is essential to natural history that the nomenclature be universal, so it is indispensable that the names be written in some language adopted by all nations, and they have been therefore formed either from the Greek or Latin. Priority of names must be strictly attended to, if published and given according to the established rules, as otherwise it would occasion much confusion No manuscript or unpublished names ought to be attended to. Generic names, giving the idea of a group, ought to be substantives, and ought to be derived from some character common to all the known species, or in honour of some botanist; sometimes metaphorical names, derived from ancient history and mythology, have been bestowed as generic names to plants, and often their vernacular appellations. Existing names are sometimes anagrammatized, as *Galphimia* from *Malpighia*, &c., but such names are, perhaps, not desirable. Specific names should be adjectives, and when substantives, they should be in the genitive case, as when they are derived from the names of men; or they may have an adjective termination, *Ewer*iana instead of *Ewerii*. The varieties are generally indicated by the Greek alphabet, for the numbers, with a name similar to the specific name, as *Erica ventricosa*, *β. rosea*. The names of orders are generally derived from some genus which is selected as the type of the family on account of its being most generally known, as *Rosaceæ* from *Rosa*, *Portulaceæ* from *Portulaca*, &c.; but some have derived their names from general characteristic features in the orders, as for instance, *Labiatæ*, indicating all the plants in the order to have lipped flowers; *Umbelliferæ*, bearing umbels, *Leguminosæ*, bearing legumes, &c.; which are probably the best.

*Botanical style in writing* is the art of characterising and describing plants, so that they may be ascertained by others; the rules laid down by Linnæus have been invariably followed since his time. A character, in natural history, is a peculiarity by which one plant may be distinguished from all others. When it is intended to distinguish species it is called a specific character, when genera, generic character, when orders, ordinal character.

The great advantage of characters is to compare the peculiarities of one species with others, or one genous with others, &c. The orders or families are founded on the same principles as the genera, being merely genera of a more comprehensive nature, as a genus is a group of species having a close relationship or affinity to each other, but whose characters are of a less important nature than that of the order itself. When the genera of any particular order are numerous, they are generally grouped into suborders or tribes, whose characters are of less importance than those of the orders, but greater than those of genera.

The manner of describing classes, orders, suborders, and tribes may be seen at the end of this Treatise; and that of genera and species in the alphabetical part of the *Miscellaneous* division.

## Part II.—Systematic Botany, or Classification of Plants.

*General objects of classification.*—We have now arrived at that important branch of the subject which treats of the nomenclature and arrangement of plants, and of the means by which we are enabled to discriminate one species from another, and to combine them into genera, families, or orders, classes and subclasses. It is evident that without some aid of this kind all our observations on vegetable life would be rendered of little value, as we should be unable, unassisted by such means, to convey to others a correct notion of the plants which formed the subjects of our experiments and observations. The necessity of some help to the memory becomes still more evident when we reflect on the multitude of species which compose the vegetable kingdom, and that the number already known amounts to above 60,000. But, independent of these considerations, systematic botany presents still higher claims to our regard, for through it we catch a glimpse of that infinitely vast and beautiful plan, of which we everywhere behold traces, upon which the great Author of nature appears to have proceeded in the work of creation, and thus admitting the human mind, as far as its imperfect nature will permit, to a view of the universe as it was originally designed. As something has already been said upon the merits of various botanical arrangements which have been from time to time proposed, it will be necessary here to confine ourselves on this occasion to giving an illustration of the arrangements according to the natural affinities, or as it is termed the natural system. The natural system is founded upon the consideration of the entire structure of the plant, while the Linnæan artificial system is founded upon the consideration of a few points, namely, the number and arrangement of stamens and pistils, as has already been shown. By the former we combine plants according to the degree of relationship in which they stand to each other, and we not only arrive by means of it at their names, but likewise at a complete knowledge of the structure, affinities, and properties. A knowledge of the structure of a plant determines at once its affinity, and a knowledge of its affinities enables us to judge of its structure and properties. An artificial system can only serve as a guide to the names of plants, without conveying any other information respecting them. It has been found expedient to divide the vegetable kingdom into groups of different degrees of importance, termed classes, subclasses, orders or families, genera, species, and varieties. The subclasses, orders, and genera may be again subdivided into cohorts, suborders, tribes, and sections.

In the natural classification, after becoming acquainted with the class, we may presume its organization and all its consequences, as well as the family or order to which a plant belongs. As this resemblance may be partial, we must consider the various organs in all their relations, and the more complete this comparison is the more perfect will the system be.

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*Relative importance of organs.*—In determining the particular group to which a plant belongs, it is necessary to compare its *characters* with those of other species. By the term "*characters*," we mean the peculiar appearances presented by different organs: thus a leaf may be round, ovate, lanceolate, &c.; the petals may be united, undeveloped, or abortive, &c.; and these adjectives denote the peculiar characters of these organs. It will readily be understood that some characters must be of much greater importance than others, in determining the affinities of different species. Thus the first degree of affinity in phænogamous plants is almost always to be ascertained by a single character residing in the embryo, and we may determine at once to which of the two primary groups or classes it belongs, by attending to this circumstance alone. But even here this important distinction may be so far disguised or modified, as inevitably in some instances to lead to error, if it were not possible to check our observations by other considerations, of secondary importance in most cases, but which, in the present instance, are quite sufficient to correct our judgment, and to satisfy us of the real affinities of the plant in question; thus in the genus *Cuscuta*, the characters of the flower, the structure of the stem, and other circumstances, clearly indicate that it belongs to the class "*Dicotyledones*," although the embryo has no cotyledons, and the stem is leafless. The inference to be drawn from these facts is, that the cotyledons and leaves are abortive, and hence we might expect, if ever such a phenomenon should occur as a leafy *Cuscuta*, that its cotyledons would certainly resemble those of other "*Dicotyledones*." When the class of any plant has been determined by the presence of some one character, or by the combination of several, we next view our search for other characters of a less general description, to ascertain the "order" or "family" to which it belongs; and when we have found the order, we must descend to still more minute particulars for fixing the "genus." It is therefore of the utmost importance to these inquiries, that an accurate subordination of characters should be established; and for this purpose a few rules have been framed, which are the result of an extended examination of facts or the deductions of common sense. We must remark that the comparison can only be made between two organs which belong to the class of functions; the nutritive organs must therefore be compared together, and the reproductive together, in order to establish a subordination in each series respectively. We may, however, afterwards determine whether one of these two functions cannot be considered more important than the other, and then we shall also be able to establish something like a fresh relation between the several degrees which had been previously settled for the two series of organs. Suppose for example it were determined that the cotyledons are among the organs of most importance to the nutritive system, and the root among those of the next degree. Now, if it were also determined that the nutritive function was of more importance than the reproductive, then the cotyledons will be of more value than the stamens. But, although the root may be of more importance than the corolla, it does not follow that it is necessarily of more than the stamens; it may be of equal or less importance. In this latter case we are comparing an organ of second-rate importance in the one series, with one of the first-rate importance in the other. If we could determine the natural affinities of all plants from a comparison of all the characters deduced from one series alone, and could likewise determine their natural affinities from characters belonging to the other series, it is evident that the two arrangements thus established would strictly coincide. In the establishment of the minor groups, botanists have recourse almost exclusively to the reproductive organs; as their characters are much better defined, and more varied than those of the nutritive organs. The larger groups, however, are chiefly determined by characters belonging to the nutritive and elementary organs, where the exogenous structure tallies with the dicotyledonous embryo, and the endogenous with the monocotyledonous. The following rules may be advantageously consulted for determining a subordination of characters in one or other series: 1. where two organs belonging to different classes of functions have the same relative value in the respective series, that organ will possess the greatest value which belongs to the most important function: 2. those organs of the same series are of the greatest value which are of most general occurrence; thus the cellular tissue, which is universally present, is the most important element in vegetation: 3. the adhesion which generally subsists between an inferior and a superior organ, serves to point out the relative value of any of the two of the former; since it will be of the same as that which was previously established for those of the latter, to which they respectively adhere: 4. the greater degree to which an organ is liable to vary, indicates an inferiority in its value; thus the shape of the leaves is of little importance beyond determining the specific distinctions of plants, and in many cases is even of no further use than in discriminating certain varieties of the same species: 5. the relative periods at which different organs are formed and developed may also be taken as some test of their importance, those which are the earliest formed being considered more important than others with which they are immediately connected, and of the same class. By attention to these, and a few other rules of less general application, a subordination of characters has been established, of which the chief results are the following:—

| Elementary. | Nutritive. | Reproductive. |
|---|---|---|
| Relative values:<br>1. Cellular.<br>2. Vascular.<br>α. Spiral vessels.<br>β. Ducts. | Embryo and sporule:<br>α. Cotyledons.<br>β. Radicle.<br>γ. Plumule. | |
| 3. ............... | Roots, stem, leaf, frond, thallus. | 1. Stamens and pistils.<br>2. Fruit, pericarp, theca. |
| 4. ............... | .................... | Floral envelopes:<br>α. Corolla.<br>β. Calyx.<br>γ. Perianth. |
| 5. ............... | .................... | Inflorescence, torus, nectary, bractea, involucrum. |

Besides the relative values of different organs we may estimate the relative value which two organs of the same kind bear to each other in different species. This will depend upon the greater or less perfection which they exhibit in their respective modes of developement; also upon their position, connection with other organs, and numerous other particulars which it is impossible to define with any degree of precision, and which practice alone can enable the systematic botanist duly to appreciate. A species is a collection of all those individuals

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which have greater resemblance among themselves than with other plants, and which may by fecundation one by another produce fertile individuals, which in their turn reproduce others, agreeing in all the essential characters of vegetation and fructification. A genus is a collection of those species which have in themselves a more striking resemblance in their organs than they have to the organs of others; it therefore bears the same relation towards species as a species does towards individuals; agreeing in all the essential characters of fructification, and also in habit. An order or family is an assemblage of genera, having a greater resemblance among themselves than with other genera; agreeing in the more important characters of vegetation and fructification. A class consists of an assemblage of natural orders or families, connected by a few important characters common to their nutritive and reproductive systems. When a variety of any species is reproducible by seed, and retains its peculiarity pretty constant without returning to the more common type, it is termed a race; but when its distinguishing characters are transient, and may be modified by a change of soil or situation, it is only a variety. In this way a subordination among the natural groups is established, into which plants may be arranged. As the classes and orders of Jussieu have already been described and compared with those by De Candolle in a former part of this treatise, it will be unnecessary to say any thing further here on the subject, but proceed to give characters of all the natural orders, arranged according to the latter plan, now generally followed.

## Part III.—Arrangement and Characters of the Natural Families, or Orders and Tribes.

First grand division, *Vasculares* or *Cotyledoneæ*, De Candolle.—This division contains all the flowering plants. They are composed of woody fibre, cellular tissue, and spiral vessels, and furnished with true leaves. The embryo furnished with evident cotyledons or seed leaves, inclosed within a seed cover. The flowers are usually distinct and symmetrical. The present division contains all the Linnæan classes, with the exception of *Cryptogamia*.

First class, *Dicotyledoneæ*, or *Exogenæ*, De Candolle.—The embryo is furnished with two cotyledons or seed leaves, which are usually simple, but sometimes divided; the plumule in the centre of their point of junction; the inferior end of the embryo lengthened out into a simple radicle or first root. The stems increase by external layers, with an evident distinction between bark and wood. The leaves are traversed by branched veins. Parts of flower generally disposed by fives.

First division, *Dichlamydeæ*, De Candolle.—In this division the perigone is double, that is, the flower has both a calyx and corolla present.

First subclass, *Thalamifloræ*, De Candolle.—The calyx is composed of several separate sepals, and the corolla of several distinct petals. The petals as well as the stamens are inserted into the thalamus or receptacle. The insertion of the petals and stamens is the principal character of this subclass, and is founded on the same rule as the class *Polyandria* of Linnæus, but without any reference to number. *Hypopetalæ*, Jussieu.

First cohort. Carpels numerous, distinct, crowded, rarely solitary by abortion or coalition, each bearing a style. Receptacle bearing or girding the ovaries, and, from the same cause, bearing the stamens, petals, and sepals on the outside. The stamens indefinite, or, if definite, they are opposite the petals.

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Order 1. *Ranunculaceæ*, Jussieu.—Calyx of several definite petals, or many-parted; petals definite or indefinite, but sometimes wanting; stamens indefinite, free; anthers, adnate, bursting outwards; carpels indefinite, one-celled, capsular, baccate or follicular, one or many-seeded; seeds erect or pendulous, attached by their inner side, or, if many, usually disposed in a row along the inner edges of the carpel or follicle; embryo minute, placed at the base of a horny albumen. This order consists of herbs, undershrubs, or climbing shrubs, with simple or variously cut, usually alternate leaves, having the petioles dilated at the base. The properties of them are acrid and venomous. The order is divided into four tribes. Tribe 1. *Clematideæ*. Distinguished from the rest in the sepals being valvate or induplicate in the bud, and the petals wanting; the carpels indehiscent, one-seeded, ending each in a feathery tail; seeds pendulous. Usually climbing shrubs with opposite leaves. Example, *Clematis*. Tribe 2. *Anemoneæ*. Æstivation of both calyx and corolla imbricate; petals flat or wanting; carpels one-seeded, indehiscent, each ending in a tail or point; seeds pendulous; herbs with radical or alternate leaves. Example, *Anemone*. Tribe 3. *Ranunculeæ*. Æstivation of calyx and corolla imbricate; the petals bilabiate or increased by a scale inside at the base; carpels one-seeded, indehiscent; seeds erect; herbs with radical and alternate leaves. Examples, *Ranunculus* and *Myosurus*. Tribe 4. *Helleboreæ*. This differs from the last in the calyx being petal-like, in the petals being often wanting, but when present, they are irregular, bilabiate, or nectariferous, and in the carpels being capsular or follicular, and many-seeded. Herbs with radical and alternate leaves. Examples, *Helleborus*, *Trollius*, *Aconitum*, *Delphinium*. Tribe 5. *Pæoniaceæ*. This is an anomalous tribe, differing from all others in the anthers bursting outwards; the carpels are dry or baccate, follicular, and many-seeded. Examples, *Actæa*, *Pæonia*.

2. *Dilleniaceæ*, De Candolle.—Calyx of four or five persistent sepals; stamens indefinite, free; anthers adnate, bursting inwards; ovaria indefinite, rarely fleshy, or combined into a single fruit; carpels, when separate, two-valved; seeds attached by their inner angle, disposed in two rows along the sutures of the carpels, seldom solitary; embryo minute, located at the base of horny albumen. This order is composed of trees and shrubs, or climbing shrubs, with alternate, feather-nerved, simple, entire, or toothed leaves. The properties are astringent. The leaves are rough, and some so much so as to be used in polishing. The order is divided into two tribes. Tribe 1. *Delimaceæ*, which is distinguished by the filaments being dilated at their apices, and bearing on both sides the separated roundish cells of the anthers. Examples, *Tetracera*, *Delima*. Tribe 2. *Dilleneæ*. In this the filaments are not dilated at their apices, but bear on both sides the elongated cells of the anthers. Examples, *Dillenia*, *Hibbertia*, *Candollea*.

3. *Magnoliaceæ*, De Candolle.—The calyx is composed of three or six sepals, and the petals three to twenty-seven, disposed in ternary series; stamens indefinite, free; anthers adnate; ovaria numerous, rarely combined at maturity; embryo erect, inferior; albumen fleshy. The order is composed of magnificent trees and shrubs, with alternate, feather-nerved, simple, entire, or sublobate leaves, which are involute in the bud.



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There are present two deciduous convolute stipulas, enveloping the young leaves before expansion. Astringency is the principal property of this order. The Winter's bark, known for its resemblance to *Amomon*, is of this family. It is divided into two tribes. Tribe 1. *Wintereæ*. Is distinguished by the carpels being disposed in whorls, and in the leaves being full of pellucid dots. Examples, *Illicium, Drimys*. Tribe 2. *Magnolieæ*. Distinguished by the carpels being two-valved and disposed in spikes along the axes, and in the leaves being destitute of pellucid dots. Examples, *Magnolia, Liriodendron*.

4. *Anonaceæ*, Richard.—Calyx trifid; petals three or six by threes; stamens indefinite; anthers nearly sessile, tetragonal; ovaria numerous, rarely combined at maturity; embryo straight; albumen pierced by the seed-coat. Composed of trees and shrubs, with alternate, feather-nerved, entire, rarely lobed leaves. It differs from the last in the absence of stipulas, and different structure of the fruit, seeds, and anthers. Some of the trees bear esteemed fruit for the dessert, and the seeds of the dry fruited kinds are aromatic and pungent, and are used as condiments. The order is divided into two sections, distinguished by their combined or separate carpels. Examples, *Anona, Unona, Monodora*.

5. *Schizandraceæ*, Blume.—The flowers in this order are monoecious or dioecious, the sepals are three, and the petals nine to twelve, ternary. Stamens connate or free, few or many; anthers bursting outwards; carpels baccate in a long spike along the elongated torus; albumen fleshy; embryo straight. Composed of climbing shrubs with simple leaves, and axillary and lateral one-flowered peduncles. This differs from the next order in the presence of albumen, and in the elongated torus, and from *Anonaceæ* in the albumen not being pierced by the seed-coat.

6. *Menispermaceæ*, De Candolle. — Flowers unisexual; sepals and petals definite in number, deciduous; stamens in the male flowers monadelphous, rarely free, equal in number to the petals then opposite them, or many times that number; anthers adnate, bursting outwards; in the female flowers the ovaria are few, rarely combined; the carpels baccate, compressed, usually lunulate like the seeds; albumen wanting; embryo curved, with distant cotyledons. Composed of climbing shrubs without stipulas; the leaves alternate and simple, rarely compound. The properties of the plants are bitter and febrifugal. The famous Columbo-root belongs to this order. This differs from the last and other allied orders in the definite stamens, structure of the fruit, and from *Berberideæ* in the stamens being opposite the petals. It is divided into two tribes. Tribe 1. *Lardizabaleæ*, which is distinguished by the carpels being numerous and distinct, one or many-celled, many-seeded, and in the leaves being compound. Example, *Lardizabala*. Tribe 2. *Menispermeæ*, in which the carpels are one-celled and one-seeded. Examples, *Menispermum, Cocculus, Cissampelos*.

7. *Berberideæ*, Ventenat.—Sepals deciduous in two series, two or three in each, and opposite the petals; stamens equal in number to the petals and opposite them; anthers adnate, dehiscing by a valve from the base to the apex; ovarium solitary; fruit baccate; seeds attached laterally to the inner margin; albumen fleshy; embryo erect, slender. Composed of shrubs and herbs, with alternate, simple, but usually compound leaves, and racemose, bracteolate, yellow flowers. The singular dehiscence of the anthers distinguishes this order from all others in the *Thalamifloræ*. The berries of some species of *Berberis* are acid, and form with sugar an agreeable preserve. Examples, *Berberis, Nandina, Leontice, Epimedium, Diphylleia, Bongardia*.



8. *Podophylleæ*, De Candolle.—Sepals three or four; petals in one or many series, alternating with the sepals; stamens equal in number to the petals then opposite them, or in many rows; anthers terminal, bursting inwards by a double chink; ovaria one, two, or more, indehiscent; fruit succulent; seeds inverted; albumen fleshy; embryo thick, straight, basilar. Composed of herbs delighting in shade, with petiolate, lobed, peltate-nerved leaves, and bractless one-flowered peduncles. The roots are purgative, the herbs narcotic, and the berries edible. The order is very nearly allied to *Ranunculaceæ*, tribe *Pæoniaceæ*, from the dehiscence of the anthers, and ought probably to be joined with it.

9. *Nymphæaceæ*, Sal.—Sepals four or five, inserted in the thalamus, not articulated; petals and stamens disposed in many series, alternating with the sepals; anthers adnate, bursting inwards by a double chink; thalamus of flower expanded, bearing the sepals, petals, and stamens on the outside, and surrounding more or less completely the ovaria; ovaria numerous, free, or combined within the thalamus. Composed of aquatic herbs, with thick creeping rhizoma, and long, petiolate, usually peltate leaves, and bractless, one-flowered peduncles. It is distinguished from *Papaveraceæ*, to which it is nearly allied, by the persistent sepals. The order is divided into two tribes. Tribe 1. *Nelumboneæ*, which is distinguished by the carpels being separate, one or two-seeded, each bearing a style; they are half immersed in pits in the elevated torus. Example, *Nelumbium*. Tribe 2. *Nymphæeæ*, in which the carpels are many-seeded, and inclosed within the torus, having the stigmas radiating upon the top of the fruit. Examples, *Nymphæa, Nuphar, Euryale, Victoria*.

10. *Hydropeltideæ*.—Sepals three to four, coloured; petals equal in number to the sepals, and alternating with them; stamens six to thirty-six, disposed in two or many rows; filaments capillary; anthers ovate or linear, bursting by a double chink inside, terminal; carpels two to eighteen, baccate or capsular, indehiscent, one or two-seeded; seeds inverted or pendulous; albumen rather farinaceous; embryo small, basilar. Composed of floating aquatic herbs, with entire, peltate, or multifid leaves, one-flowered axillary peduncles, and purple or yellow flowers. It differs from *Podophylleæ* in the numerous ovaria, in the longer styles and definite seeds; it differs also in the latter respect from *Nymphæaceæ*, to which it is more nearly allied.

Second cohort. Carpels solitary or connate; placentas parietal, intervalvular; calyx of two or five sepals; petals four or five, rarely more; stamens numerous, but usually five or six. The position of the placentas in the centre of the valves is the principal character in this division.

11. *Sarraceniaceæ*, Turpin.—Calyx of five permanent sepals, propped by a three-leaved involucrum; petals five, unguiculate at the base; stamens numerous, crowded; anthers fixed by their backs, oblong, opening upwards from the base; style columnar, crowned by a broad, convex, foliaceous, five-angled stigma; capsule globose, crowned by the persistent style and stigma, five-lobed, five-celled, five-valved, and many-seeded; placentas five, progressing from the central axis; seeds small,

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 tubercled; embryo at the base of a waxy-granular albumen. Composed of well-known singular plants, natives of American swamps, remarkable for the singular form of their leaves, which are tubular and hold water, and some have lids. The scapes are radical, one-flowered; the flowers large and drooping. This order is readily distinguished from all others by the peltate, foliaceous stigma and the club-shaped intervalvular placentas. Example, *Sarracenia*.

12. *Papaveraceæ*, Jussieu.—Calyx of two deciduous sepals, inclosing the flower, or calyptrate; petals usually four; stamens indefinite; anthers inserted by their bases opening by two furrows; style short or wanting; stigmas two or more, usually stellately disposed; capsules composed of two or many carpels inclosed by a production of the thalamus; placentas equal in number to the carpels, intervalvular; seeds usually numerous, covering both sides of the placentas, except in those with silique-formed capsules, in which they are borne on the margins; embryo small, placed at the base of an oily albumen. Generally composed of herbaceous plants, yielding milky juice of various colours, with alternate, usually sessile, half-stem clasping, generally glaucous leaves, which are usually pinnate-lobed; peduncles one-flowered. The properties of this order are narcotic, as opium. It is distinguished from all allied orders by the intervalvular placentas and the two deciduous sepals. Examples, *Papaver, Argemone, Eschscholtzia, Glaucium, Chelidonium, Sanguinaria*.

13. *Fumariaceæ*, De Candolle.—Sepals two, small, deciduous; petals four, irregular, connected at the base or free, and sometimes the lower one is alone free, one or both of the two outer saccate at the base, the two inner callous at the apex, where they cohere and inclose the anthers and stigma; stamens six, generally connected into two bundles, which appear two three-anthered filaments, rarely free; style filiform; stigma bilamellate; capsule two-valved, silique-formed, many-seeded, or valveless and one-seeded; albumen fleshy; embryo straight. Composed of herbaceous plants yielding watery juice, with compound alternate leaves. Properties almost the same as those of *Cruciferæ*. This order differs from *Papaveraceæ* in yielding a watery instead of milky juice, and in the petals being irregular, as well as in the stamens being diadelphous, and from *Cruciferæ* by the two latter points. Examples, *Fumaria, Dielytra, Corydalis*.

14. *Cruciferæ*, Jussieu.—Sepals four; petals four, crosswise, distinct; stamens six, the two opposite the lateral sepals shortest, and inserted lower down; anthers two-celled, dehiscing inwards; torus small, bearing glands between the petals and stamens; ovarium solitary, short or elongated; style long or short; stigmas two, approximate; capsule either a silicle or silique, generally two-celled and two-valved, rarely one-celled, the cells usually separated by a thin vertical dissepiment, which is girded by a placentiferous nerve; seeds solitary or numerous in the cells, fixed to both sides of the placenta, generally hanging by umbilical funicles; albumen none; embryo curved, oily; radicle terete, pointing to the umbilicus; cotyledons opposite, inclining various ways above the radicle. Composed of herbs rarely subshrubs; the young roots always tipped by a sheath called the coleorhiza, which is conspicuous at the leaf end of the Radish; leaves simple, often radical, usually alternate, rarely opposite, entire toothed, pinnatifid, lyrate, or variously dissected; racemes opposite the leaves and terminal. The tetradynamous stamens, want of albumen, structure of pods, seeds hanging by funicles, are sufficient to distinguish this order from all its allies. The properties are antiscorbutic. Mustard, Sea-kale, Cabbage, Cauliflower, Turnip, Radish, Horseradish, Water Cress, &c., belong to this order. The order is divided into two suborders, and these again into tribes. Suborder 1. *Pleurorhizeæ*. Cotyledons flat, accumbent; radicle lateral; seeds compressed. This suborder is separated into the following tribes: 1. *Arabideæ*; 2. *Alyssineæ*; 3. *Thlaspideæ*; 4. *Euclidieæ*; 5. *Anastaticeæ*; 6. *Cakilineæ*. Examples, *Arabis, Alyssum, Thlaspi, Euclidium, Anastatica, Cakile*. Suborder 2. *Notorhizeæ*. Cotyledons flat, incumbent; radicle dorsal; seeds ovate, immarginate. This suborder is separated into the following tribes: tribe 7. *Sisymbreæ*; 8. *Camelineæ*; 9. *Lepedineæ*; 10. *Isatideæ*; 11. *Anchonieæ*. Examples, *Sisymbrium, Camelina, Lepidium, Isatis, Anchonium*. Suborder 3. *Orthoploceæ*. Cotyledons incumbent, folded together or plaited lengthwise through the middle, and enwrapping the radicle in the recess; style usually enlarged with a cell and seed at its base; seeds generally globose, always immarginate. This suborder is divided into the following tribes: 12. *Brassiceæ*; 13. *Velleæ*; 14. *Psychineæ*; 15. *Zilleæ*; 16. *Raphaneæ*. Examples: *Brassica, Vella, Psychine, Zilla, Raphanus*. Suborder 4. *Spirolobeæ*. Cotyledons incumbent, linear, spirally or rather circinately twisted. This suborder divides into the following tribes: 17. *Buniadeæ*; 18. *Erucarieæ*. Examples, *Bunias, Erucaria*. Suborder 5. *Diplecolobeæ*. Cotyledons incumbent, linear, with two legs or a double plait, that is to say, plaited twice crosswise. This suborder is divisible into the following tribes: tribe 19. *Heliophileæ*; 20. *Subularieæ*; 21. *Brachycarpeæ*. Examples, *Heliophila, Subularia*, and *Brachycarpa*. Suborder 6. *Schizopetaliceæ*. Cotyledons four, spirally twisted; petals pinnatifid. Example, *Schizopetalon*.

15. *Capparideæ*, Jussieu.—Sepals four; petals four, cruciate, usually unguiculate, equal or unequal; stamens numerous, rarely tetradynamous; torus round or elongated; ovarium stipitate; fruit variable, siliquose or baccate, dehiscent or indehiscent, one-celled; seeds usually kidney-shaped; albumen none; embryo inverted. Composed of herbs, shrubs, and trees, sometimes with stipular spines; leaves alternate, simple or palmate. Properties nearly that of *Cruciferæ*. The stipitate ovarium distinguishes this order from all its allies. It is divided into two groups. Tribe 1. *Cleomeæ*. Distinguished by the capsular fruit with membranous dehiscent valves. Examples, *Cleome* and *Polanisia*. Tribe 2. *Cappareæ*. Has the fruit fleshy and indehiscent. Examples, *Capparis, Stephania*.

16. *Resedaceæ*, De Candolle.—Sepals four to six, persistent; petals four to six, open in æstivation, and alternating with the sepals, unguiculate, usually fringed or cleft, and inserted in an elevated dilated torus; stamens two or three for each petal; anthers incumbent, bursting inwards; ovarium stipitate; style none; stigma three to four-lobed; capsule angular, inflated, open at top; seeds cochleate, tubercled; albumen none; embryo curved. Composed of herbaceous plants with alternate, entire, or cut leaves, and terminal racemes of flowers. This order differs from *Cruciferæ* and *Capparideæ*, in the capsule being one-celled and open at top, and in the shape and disposition of the seeds. Example, *Reseda*.



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17. *Flacourtianeæ*, Richard.—Sepals four to seven; petals same number, and alternating with them; stamens equal in number to the petals, or double or multiple that number; ovarium sessile or stipitate; style absent or present; stigmas equal in oomber to the valves of the ovarium; fruit one-celled, fleshy or capsular, then four to five-valved; seeds few, usually enwrapped in dry pellicles, fixed to branched placentas; albumen fleshy; embryo straight. Composed of small tropical trees or shrubs without stipulas; leaves alternate, simple; peduncles axillary, many-flowered; fruit, when fleshy, edible. The order is divided into four tribes. Tribe 1. *Patrisieæ*, is distinguished by hermaphrodite apetalous flowers, and five sepals. Example, *Patrisia*. Tribe 2. *Flacourtieæ*, in which the flowers are dioecious and apetalous, and the fruit baccate and indehiscent. Example, *Flacourtia*. Tribe 3. *Kiggelarieæ*. Flowers dioecious; petals five; fruit baccate, dehiscent. Tribe 4. *Erythrospermeæ*. Flowers hermaphrodite; petals and stamens five to seven; fruit baccate, at length dehiscent. Example, *Erythrospermum*.

18. *Bixineæ*, Kunth.—Sepals four to eight, imbricate in æstivation; petals five or wanting; stamens indefinite; ovarium sessile, one-celled; style undivided or two to four-cleft; fruit capsular or baccate, one to two-celled, many-seeded; seeds enwrapped in a fleshy membrane or pulp; albumen fleshy; embryo straight or curved. Composed of tropical trees, with alternate, entire, or lobed leaves and deciduous stipulas. The *Arnotta* is the produce of this order. Branched placentas and enveloped seeds are the principal characters of this order. Examples, *Bixa*, *Prockia*.

19. *Cistineæ*, De Candolle.—Sepals five, persistent, two outer ones smaller; petals five, caducous, twisted before expansion like the sepals, but in a contrary direction; stamens usually indefinite; anthers inserted by their bases; style filiform; stigma simple; capsule three to five-valved, rarely ten-valved, with a simple more or less projecting placenta in the middle of each valve, the seeds are therefore either parietal, or fixed to the projecting placentas; albumen mealy; embryo spiral or curved. Composed of shrubs or herbs with simple feather-nerved leaves, the lower ones always opposite, the rest alternate or opposite, usually furnished with twin foliaceous stipulas; racemes usually recurved, the unexpanded part turned back, the flowers expanding from the base. The æstivation of the petals and sepals, the regular flowers, and fugacious petals, distinguish this order from all its allies. The Gum Ladanum is the produce of a species of *Cistus*. Examples, *Cistus* and *Helianthemum*.

20. *Violarieæ*, De Candolle.—Sepals five, persistent, equal or unequal; æstivation imbricate; petals five, alternating with the sepals, equal or unequal, but when they are unequal the lower one is in the form of a labellum, which is furnished with a spur or hollow at its base; stamens five, filaments dilated, drawn out beyond the anthers in irregular flowers, two of which are drawn out into filiform appendages or nectarial glands, which are hidden within the spur or hollow; anthers bursting inwards; ovarium one-celled, three-valved; placentas parietal, one in the middle of each valve; albumen fleshy; embryo straight. Composed of herbs or shrubs, with usually alternate, simple, or lobed leaves, which are involute in the bud, and all furnished with stipulas; peduncles or pedicels bracteate. The roots of all are emetic, like the *Ipecacuanha*. The order differs from *Polygaleæ* in the one-celled fruit and stipulate leaves, and from *Droseraceæ* in the involute stipulate leaves and solitary style. It is divided into two tribes. Tribe 1. *Violeæ*. Distinguished by the irregular flowers. Example, *Viola*. Tribe 2. in which the flowers are regular: Example, *Hymenanthera*.



21. *Droseraceæ*, De Candolle.—Sepals five, persistent; æstivation imbricate; petals five; stamens equal in number to the petals, or double or quadruple that number; ovarium sessile; styles one to five, joined at the base or free, usually divided at apex; capsule one to three-celled, three to five-valved, edges of valves bent inwards; seeds disposed in two rows along the placentiferous nerves, or crowded at the bottom of the capsule; they are naked or arillate; albumen cartilaginous or fleshy; embryo straight, slender. Composed of herbs, natives of bogs. They are usually remarkable for the abundance of glandular hairs, as *Drosera*, and sometimes remarkably smooth, as *Parnassia*. The leaves are alternate, always rolled up in a circinate manner in the unexpanded state, so remarkable in Ferns and *Cycadeæ*. The young peduncles are also rolled up in the same manner as the leaves. The medicinal properties are not well known: the leaves of all have the power of curdling milk. This order is distinguished from all others by the singular habit of the plants, of which *Drosera*, *Dionæa*, and *Parnassia* give a good idea, and the circinate manner in which the young leaves and peduncles are rolled up.

22. *Polygaleæ*, Jussieu.—Sepals five, imbricate in æstivation, the two inner ones petal-formed, and the three outer smaller; petals three to five, more or less connected with the stamens; stamens monadelphous, divided at top into two equal four-anthered bundles; anthers one-celled, opening each by a pore at top; stigma funnel-shaped or two-lobed; ovarium solitary, one, two, or three-celled; fruit capsular or baccate, one to two-celled; seeds solitary in the cells, pendulous, usually with an arillate caruncle or tuft of hairs at the base; embryo straight, flat; albumen generally thin. Composed of herbs or shrubs, abounding in cream-coloured or white juice, with entire, usually alternate leaves, and the flowers disposed in racemes. This truly natural order is referable to *Leguminosæ* and *Fumariaceæ*, in habit and form of flowers. In the situation, disposition, and number of stamens it agrees with *Fumariaceæ*, but the form of the flowers and habit brings it nearer to *Leguminosæ*. The properties of this order are tonic and astringent; such is the Rattany-root of Chili, *Krameria triandra*, and *Polygala Senega*, or Snake-root. Examples, *Polygala*, *Muraltia*, *Mundia*, and *Securidaca*.

23. *Tremandreæ*, R. Brown.—Sepals four to five, unequal, deciduous; æstivation valvate; petals equal in number to the sepals, and alternating with them, involute in æstivation, including the stamens, also deciduous; stamens double the number of the petals, two in front of each; anthers inserted by their bases, two to four-celled, each cell opening by a pore or tube at apex; capsule compressed, two-celled, two-valved, with a dissepiment in the middle of each valve; seeds with a naked umbilicus, and terminated by a caruncle-formed appendage; embryo cylindrical; albumen fleshy. Composed of heath-like shrubs, natives of New Holland, covered with glandular hairs. The leaves are alternate or verticillate, without stipulas, entire or toothed, and the peduncles axillary, solitary and single flowered. This order is considered to be nearly allied to *Droseraceæ*, but differs from it and all others in the cells of the anthers. Examples, *Tetratheca*, *Tremandra*.

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24. *Pittosporeæ*, R. Brown.—Sepals five, deciduous, free or united at the base with an imbricate æstivation; petals five, united or conniving by the claws, with spreading lamina and imbricate æstivation; stamens five, free, alternating with the petals; style crowned by as many stigmas as there are cells in the ovarium; fruit capsular or baccate, cells many-seeded; seeds generally covered with glutinous pulp; embryo minute; albumen fleshy. Composed of trees, shrubs, and climbing shrubs, with alternate, simple, feather-nerved, usually entire, leaves, without stipulas; flowers terminal or axillary. The seeds being enveloped in resinous pulp, and the imbricate æstivation of both sepals and petals distinguishes this order from all its allies. Examples, *Pittosporum, Billardiera, Sollya.*

25. *Brexiaceæ*, Lindley.—Calyx small, persistent, five-parted, with an imbricate æstivation; petals five, imbricate in æstivation; stamens five, hypogynous, rising from a narrow, toothed cup; anthers ovate, innate, two-celled; style continuous, terminated by a simple stigma; drupe five-celled, many-seeded; seeds attached to a central placenta; albumen none; embryo straight; radicle cylindrical, pointing to the hilum; cotyledons ovate, obtuse. Composed of trees with almost simple stems, alternate leaves, furnished with small, deciduous stipulas; flowers green, in axillary umbels, which are surrounded by bracteas on the outside. This order agrees with *Pittosporeæ* in the hypogynous insertion and definite number of the stamens, and the many-seeded fruit. Example, *Brexia.*

26. *Tamariscineæ*, Desvaux.—Calyx four to five-parted, persistent, with an imbricate æstivation; petals four to five, inserted into the base of the calyx, marcescent, with an imbricate æstivation; stamens equal in number to the petals, or twice that number, free or monadelphous; ovarium superior; style short; stigmas three; capsule trigonal, three-valved, one-celled, many-seeded; placentas three, either at the base of the cell, or along the middle of the valves; seeds erect or ascending, oblong, compressed, comose at the apex; albumen none; embryo straight; radicle inferior; cotyledons oblong, plano-convex. Composed of shrubs with twiggy branches, alternate, acerose, or scale-formed, entire, usually glaucous leaves, and spikes or racemose-spikes of bracteate white or red flowers. From the hypogynous insertion of the stamens and parietal placentas this order comes near to *Frankeniaceæ*. The bark of the species is slightly bitter and tonic. Their ashes contain a large quantity of sulphate of soda. The Manna of Mount Sinai is found on *Tamarix mannifera*, but whether the exudation of the plant, or the deposition of an insect, is not yet properly ascertained. Examples, *Tamarix, Myricaria.*

27. *Frankeniaceæ*, St. Hilaire.—Sepals four to five, united at base, persistent, narrow, usually equal; petals four to five, alternating with the sepals, sometimes sessile, and sometimes unguiculate; claws length of calyx; limbs spreading, the throat is then furnished with petal-like scales, as in *Caryophylleæ*; but when the petals are sessile, there is a five-petalled or five-toothed urceolus between them and the stamens; stamens definite or indefinite, when definite alternating with the petals; anthers opening laterally by two pores at apex; style simple, bifid or trifid; capsule one-celled or incompletely three-celled, two to three-valved; valves bearing seminiferous placentas on their margins on both sides; seeds small, numerous; embryo straight; albumen fleshy. Composed of herbs and shrubs, with opposite, alternate, verticillate or crowded, entire, ciliated, or toothed, stipulate or exstipulate leaves. When the stipulas are present, they are usually fringed, but when absent, the bases of the leaves are drawn out into stem-clasping membranes, which are generally furnished with glands. Flowers small; when axillary, they are solitary, when terminal, they are disposed in corymbs. This differs from all the neighbouring orders by the seeds being fixed to the edges of the valves to marginal placentas, not as in *Violarieæ*, to intervalvular placentas, nor like *Caryophylleæ*, to central placentas. The order is divided into two tribes. Tribe 1. *Frankenieæ*, in which the petals are unguiculate, and the sepals united at the base, and the stamens six. Example, *Frankenia*. Tribe 2. *Sauvageæ*. Distinguished by the sepals and petals being spreading and not unguiculate, usually furnished with an urceolus or inner corolla. Examples, *Sauvagesia, Lavradia.*

Third cohort. Ovarium solitary; placenta central.

28. *Caryophylleæ*, Jussieu.—Sepals four to five, more or less united, persistent, with an imbricate æstivation; petals four to five, alternating with the sepals or teeth of the calyx, unguiculate; limbs entire or bifid, usually furnished with petal-like scales in the throat; stamens equal or double the number of the petals, those that are opposite the petals are adnate to them at the base, sometimes monadelphous; anthers birimose, two-celled, usually inserted by their bases; ovary on the top of the torus two to five-valved, crowned by an equal number of filiform or clavate stigmas; capsule two to five-valved, opening at top, usually one-celled, but sometimes two to five-celled; placenta central; seeds many; albumen mealy; embryo more or less curved. Composed of herbs and subshrubs, with opposite, entire leaves, which are usually connate at the base; the flowers are terminal, solitary, or disposed in racemes, panicles, or corymbs. The central placenta in this order separates it from all the foregoing orders, and from the following order, *Lineæ*, in the cells being many-seeded, not one or two-seeded, as in that order. The order is divided into two tribes. Tribe 1. *Sileneæ*, in which the sepals are united into a cylindrical tube, which is four to five-toothed at the apex. Examples, *Dianthus, Gypsophila, Saponaria, Silene*. Tribe 2. *Alsineæ*. Distinguished by the sepals being four to five, free, rarely connected at the base. Examples, *Cerastium, Sagina, Spergula.*

29. *Elatineæ*, Cambessedes.—This is a small family, differing from *Caryophylleæ*, to which it is nearly allied, in the organization of their stigmas, of their capsules, and of their seeds; the stigmas are capitate; the valves of the capsules are bent inwards at the edges, so much so as to form dissepiments, and the seeds are without albumen. Small herbaceous plants, more nearly allied to *Caryophylleæ*, tribe 2. *Alsineæ*, than to any other. Examples, *Elatine* and *Bergia.*

30. *Lineæ*, De Candolle.—Sepals three, four, and five, nearly free, persistent, with an imbricate æstivation; petals equal in number to the sepals, and alternating with them, unguiculate, connected to the ring of the stamens, with a twisted æstivation; stamens equal in number to the petals, connected at the base, alternating with the petals, and furnished with a tooth or abortive filament between each; anthers inserted by their bases, two-celled, birimose; styles equal in number to the cells of the ovarium; capsule globose, composed of several carpels, having induplicate margins; seeds compressed; albumen fleshy; embryo straight, flat.

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Composed of herbs or undershrubs, with entire stipulate leaves and fugaceous flowers, which are either disposed in racemes, corymbs, or panicles. The order differs from *Caryophylleæ* by the capsules, but is, perhaps, more nearly allied to *Geraniaceæ*. The properties are purgative and mucilaginous. Examples, *Linum*, *Radiola*.

31. *Malvaceæ*, Jussieu.—Sepals usually five, rarely three to four, more or less connected at the base, with a valvate æstivation; petals equal in number to the sepals, and alternating with them, with a twisted æstivation, sometimes distinct, but usually adnate to the tube of the stamens at the base; stamens usually indefinite, rarely definite, combined into a column, outer ones the shortest; anthers one-celled, kidney-shaped, bursting by a transverse chink; styles equal in number to the ovaria, distinct, or combined with an equal number of stigmas; carpels disposed in a whorl round the axis, one or two-seeded, then opening by a chink inside; and sometimes many-seeded, then opening by valves which are each furnished with a dissepiment in the middle which bears the seeds; albumen wanting, embryo straight; cotyledons twisted. Composed of trees, shrubs, and herbs, with alternate, toothed or lobed, stipulate leaves. The hairs stellately branched; peduncles axillary, one or many-flowered. The properties are mucilaginous; cotton is the produce of this order. This differs from all other orders in the combined stamens, one-celled, kidney-shaped anthers and stellate hairs. It is divided into two tribes: the first is distinguished by the calyx being girded by an involucrum; examples, *Malva*, *Malope*, *Hibiscus*, *Lavatera*: and the second tribe by the calyx being naked; examples, *Sida*, *Abutilon*, *Nuttallia*.

32. *Bombaceæ*, Kunth.—This order is very nearly allied to *Malvaceæ*; it agrees with it in the one-celled, kidney-shaped anthers and convolute petals, and in habit, but differs from it in the imbricate æstivation of the calyx, in the staminiferous column being divided into five bundles at its apex. The cotyledons are also convolute. It also agrees with *Byttneriaceæ* and *Chlenaceæ* in habit, but is readily distinguished from these two orders by the one-celled anthers. Composed mostly of stately tropical trees, such as the *Baobab* of Senegal, and the noble Silk Cotton trees, or *Bombax*. Examples, *Adansonia*, *Bombax*, *Carolinea*, *Durio*, *Cheirostemon*, *Helicteres*.

33. *Sterculiaceæ*, Ventenat. Flowers unisexual by abortion; calyx four to five-lobed, deciduous, with a valvate æstivation; petals wanting; stamens four, five to twenty, monadelphous always by fours or fives; anthers two-celled; styles equal in number to the cells of the ovarium; carpels four to five, distinct, often fewer from abortion, usually pedicellate, one or more seeded, dehiscent or indehiscent; albumen fleshy or wanting; embryo erect, cotyledons foliaceous in albuminous seeds, and thick and unequal in exalbuminous seeds. Composed of umbrageous tropical trees, with alternate, simple, or compound leaves, and axillary panicles or racemes of flowers. The two-celled anthers distinguish it from *Malvaceæ* and *Bombaceæ*, and distinct carpels from *Byttneriaceæ*. The seeds of the *Chica* of Brazil and *Cola* of Africa are edible. Examples, *Sterculia* and *Heritiera*.

34. *Byttneriaceæ*, R. Brown.—Calyx naked or involucrated; sepals more or less connected at base, with a valvate æstivation; petals five, alternating with the sepals, of various forms, rarely unequal, with a convolute æstivation; stamens equal in number, or double, triple, or multiple that number, monadelphous or variously divided at top; anthers two-celled behind; albumen oily or fleshy; embryo straight. Composed of trees and shrubs, with simple, lobed, or toothed, stipulate leaves, and usually beautiful flowers. It differs from all other allied orders in the different æstivation of the calyx and corolla, except *Sterculiaceæ*, which is probably not distinct. Properties mucilaginous. *Theobroma cacao* is the Cacao or Chocolate of the shops. The order is divided into five separate tribes, which are by many considered orders. Tribe 1. *Byttnerieæ*. Petals concave, ligulate at apex; stamens ten to thirty, separated into five or ten bundles, many of them small; ovary five-celled; cells two-seeded. Examples, *Theobroma*, *Byttneria*. Tribe 2. *Lasiopetaleæ*. Calyx petaloid, five-parted; petals minute or wanting; stamens five and ten, when the latter number, five of them are sterile; carpels five, two-valved, closely connected or free. Examples, *Lasiopetalum*, *Thomasia*. Tribe 3. *Hermannieæ*. Stamens five, all fertile; carpels combined; calyx sometimes involucrated. Example, *Hermannia*. Tribe 4. *Dombeyaceæ*. Stamens numerous, rarely all fertile. Examples, *Dombeya*, *Astrapæa*. Tribe 5. *Wallichieæ*. Calyx involucrated; stamens numerous, disposed in a long tube, outer ones the shortest. Examples, *Wallichia*, *Eriolæna*.

35. *Hugoniaceæ*, Arnott.—Involucel none; sepals distinct, acute, unequal, the two outer ones lanceolate, densely pubescent, the others dimidiately ovate, and pubescent on the straight side, and testaceous and shining on the other; æstivation imbricate and quincuncial; petals five, with short claws, twisted in æstivation; stamens ten, united at the base; anthers ovate-cordate, erect, two-celled; ovarium roundish, glabrous, five-celled, seated on a slightly elevated torus; ovula two in each cell, pendulous, collateral; styles five, distinct; stigmas slightly dilated and lobed; fruit with a fleshy epicarp, enclosing five distinct, bony, one-seeded nuts or carpels; seeds pendulous; albumen fleshy; embryo in the axis; cotyledons flat, foliaceous; radicle short, superior, pointing to the hilum. Composed of shrubs with alternate crowded leaves, which are sometimes opposite near the flowers; stipulas two, subulate; peduncles axillary, one-flowered, often transformed into circinate spines by abortion. Example, *Hugonia*.

36. *Tiliaceæ*, Jussieu.—Sepals four to five, with a valvate æstivation; petals four to five, alternating with the sepals, rarely wanting; stamens free, usually indefinite; anthers two-celled, bursting lengthwise by a double chink; glands equal in number to the petals, and opposite them, adhering to the stipe of the ovarium; stigmas free, as many as there are cells in the ovarium; capsule many-celled; cells many-seeded; albumen fleshy, rarely wanting; embryo straight. Composed of herbs, shrubs, and trees, with alternate, simple, bistipulate, usually serrated or toothed leaves, and axillary, solitary, racemose, or panicled flowers. The order differs from *Malvaceæ*, *Bombaceæ*, *Sterculiaceæ*, and *Byttneriaceæ*, in the free stamens, and from the next, *Elæocarpeæ*, in the entire not fringed petals, and in the shape and dehiscence of the anthers. Examples, *Corchorus*, *Tilia*, *Grewia*, *Sparmannia*.

37. *Elæocarpeæ*, Jussieu.—Sepals four to five, with a valvate æstivation; petals four to five, alternating with the sepals, fringed or lobed; torus glandular, elevated; stamens fifteen to twenty, with short, free filaments, and elongated, filiform, tetragonal, two-celled anthers, each cell opening by a pore at the apex; ovarium many-celled; cells two or many-seeded; style one; albumen fleshy;

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embryo erect. Composed of shrubs or trees, with alternate, simple, stipulate leaves, and axillary, solitary, or racemose inflorescence. Differs from *Tiliaceæ* in the fringed or lobed petals, and the dehiscence of the anthers. Example, *Elæocarpus*.

38. *Chlenaceæ*, Pet. Thouars.—Involucrum one or two-flowered, persistent, various in form and consistence; sepals three, small; petals five, usually altogether free; stamens usually numerous, combined at the base, or adnate to the petals when they cohere at the base; anthers roundish, two-celled, adnate or free; style filiform; stigma triple; capsule three-celled, or only one-celled by abortion; cells one or many-seeded; seeds fixed to the central axis, inverted; albumen fleshy, embryo central, green. Composed of small trees, natives of Madagascar, with alternate, entire leaves, deciduous stipulas, and racemose or panicled inflorescence. The order is said to be nearly allied to *Malvaceæ*, on account of the involucrated flowers, monadelphous stamens, and in the petals being often connected at the base, and in the albuminous seeds, but differs from it in the two-celled anthers, and the want of starry hairs. Example, *Sarcolæna*.

39. *Ternstræmiaceæ*, De Candolle.—Calyx bibracteate at the base, or bractless; sepals three to five, persistent, coriaceous, obtuse, with an imbricate æstivation; petals usually five, rarely more, sometimes perfectly free, but generally connected at the base; stamens numerous, free or combined, rarely polyadelphous, with short, awl-shaped filaments, and two to four-celled, adnate, or versatile anthers; styles two to seven, free, or more or less combined; fruit radiately divided inside into as many cells as there are styles or stigmas, dehiscent or indehiscent; seeds few or many, fixed to the central placenta, arched, roundish, or compressed; albumen fleshy or wanting; embryo arched or straight, slender. Composed of trees and shrubs with alternate, exstipulate, undivided leaves, and axillary and terminal peduncles; flowers large and handsome. The Tea and the Camellia belong to this order. The seeds of some species of the latter genus yield a fine oil. The family is divided into seven tribes, which, by some botanists, are considered as so many orders. Tribe 1. *Ternstræmieæ*. Calyx bibracteate; petals connected at the base; anthers adnate; style crowned by a simple stigma; albumen fleshy. Example, *Ternstræmia*. Tribe 2. *Euryeæ*. Calyx bibracteate; corolla five-parted; anthers adnate; style crowned by three to five stigmas. Example, *Eurya*. Tribe 3. *Freziereæ*. Calyx bibracteate; petals free; anthers adnate; style crowned by two to five stigmas; albumen fleshy. Example, *Freziera*. Tribe 4. *Saurauyeæ*. Calyx bi-tribracteate; petals more or less connected; anthers incumbent; styles three to five, distinct; albumen fleshy. Example, *Sauraja*. Tribe 5. *Laplaceæ*. Calyx bractless; sepals combined or free at the base; petals distinct; anthers adnate or versatile; styles combined; stigmas free; albumen fleshy or none; seeds compressed, rarely cochleate. Examples, *Laplacea*, *Kielmeyera*. Tribe 6. *Gordonieæ*. Petals usually combined at the base; stamens monadelphous at the base; anthers oscillatory; albumen wanting. Example, *Gordonia*. Tribe 7. *Camellieæ*. Sepals five to nine; petals five to nine; stamens monadelphous or polyadelphous; anthers versatile; styles three to five; fruit three-celled, three-valved, few-seeded; albumen wanting. Example, *Camellia*.

40. *Olacineæ*, Mirbel.—Calyx persistent, toothed, at length enlarged, and fleshy; petals four to five, coriaceous, with a valvate æstivation, free or connected by pairs, having hair-formed appendages rising from them; stamens three to ten, hypogynous or epipetalous; anthers cordate-oblong, erect, two-celled; ovarium four-celled; cells one-seeded; style filiform; fruit somewhat drupaceous, one-celled, one-seeded; seed pendulous; albumen fleshy; embryo small, basilar. Composed of smooth trees and shrubs, with alternate, petiolate, exstipulate leaves, and small axillary flowers. The proper situation of this order is extremely doubtful. Examples, *Olax*, *Ximenia*.

41. *Aurantiaceæ*, Correa. — Calyx three to five-toothed, marcescent; petals three to five, free or connected a little at the base, with an imbricate æstivation; stamens equal in number with the petals or double or triple that number, free, monadelphous or polyadelphous, flat at the base; anthers terminal, erect; ovarium ovate, many-celled; style crowned by a subdivided stigma; fruit an orange, composed of many cells or carpels around a pithy axis; seeds fixed to the inner angle of the cells, usually pendulous, exalbuminous; the rind considered as a continuous torus; embryo straight. Composed of trees and shrubs with alternate, compound, or simple leaves; when simple the petiole is jointed; spines, when present, axillary. All parts of the plants, bark and wood excepted, abound in oily receptacles. This oil is odoriferous and tonic, and stimulating in its properties. The Orange, Lime, Lemon, and Shaddock represent this order. The structure of the fruit is sufficient to separate it from all other orders.

42. *Hypericineæ*, De Candolle.—Calyx four to five-parted, or of as many sepals, persistent, the two outer sepals small, all usually dotted and glandularly toothed; petals four to five, full of black dots; stamens usually indefinite, collected into many bundles, rarely free or monadelphous; anthers oscillatory; styles numerous, sometimes combined; stigmas simple, rarely capitate; capsule many-celled, many-valved, many-seeded; albumen wanting; embryo straight. Composed of herbs, shrubs, and trees, abounding in a yellow, resinous juice like that of gamboge; leaves opposite, exstipulate, rarely alternate, crenated, sessile, or on very short petioles, usually full of pellucid and black dots; flowers terminal or axillary, usually bracteate, panicled, or corymbose. The properties are bitter and slightly astringent. This family is readily distinguished from its allies from abounding in resinous juice, and from *Guttiferæ* in the oscillatory, not adnate anthers, and from *Aurantiaceæ* in the opposite simple leaves. The order is divided into three tribes. Tribe 1. *Vismieæ*. Fruit baccate, seeds terete. Example, *Vismia*. Tribe 2. *Hypericeæ*. Fruit capsular, seeds terete. Example, *Hypericum*. Tribe 3. *Eucryphieæ*. Fruit capsular, seeds flat, winged. Examples, *Eucryphia*, *Haronga*.

43. *Reaumuriaceæ*, Ehrenberg.—Calyx five-parted, surrounded by imbricate bracteas; petals five; stamens definite or indefinite; anthers peltate; ovarium superior; styles several, filiform or subulate; capsule two to five-celled, two to five-valved, with a loculicidal dehiscence; seeds definite, villous; embryo straight, surrounded by mealy albumen; radicle near the hilum. Composed of small shrubs with fleshy, scaleformed or small alternate exstipulate leaves, and solitary flowers. This small family comes nearer to *Hypericineæ* than to any other order, from which it differs principally in the succulent habit and definite villous seeds. A saline

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matter is present in the species in great abundance. Examples, *Reaumuria*, *Hololachna*.

44. *Guttiferæ*, Jussieu.—Calyx of two to four, rarely of more sepals, or five to six-parted, with an imbricate æstivation, the two outer sepals smallest; petals four to six, rarely more, free; stamens indefinite, rarely definite, free, or connected at the base or in bundles; anthers adnate, two-celled, dehiscing lengthwise, rarely by pores at the apexes; torus fleshy; style almost wanting; stigmas rarely distinct; ovarium two to eight-celled, rarely one-celled, cells one or many-ovulate; fruit capsular, dehiscent, or fleshy and indehiscent; seeds large, usually arillate; albumen wanting; embryo straight. Composed of trees, abounding in yellow resinous juice, with opposite, entire, coriaceous leaves. The Mangostan and Gamboge belong to this order. Distinguished from *Hypericineæ* in the adnate anthers, and from *Ternstrœmiaceæ*, its nearest ally, by the resinous juice and other characters. The order is divided into four tribes. Tribe 1. *Clusieæ*. Fruit capsular, dehiscent, many-celled. Example, *Clusia*. Tribe 2. *Chrysopieæ*. Cells of ovarium containing many ovula; fruit fleshy, indehiscent, many-celled. Example, *Chrysopia*. Tribe 3. *Garcinieæ*. Cells of ovarium containing a single ovula; fruit fleshy, indehiscent, many-celled. Examples, *Mammea*, *Garcinia*, *Stalagmitis*. Tribe 4. *Calophylleæ*. Fruit drupaceous, indehiscent; ovarium one to two-celled, cells one to two-ovulate. Example, *Calophyllum*.

45. *Marcgraviaceæ*, Jussieu.—Sepals two to seven, imbricate; corolla monopetalous, hoodformed, entire or jagged at apex, seldom five-petalled; stamens definite and indefinite; filaments dilated at the base; anthers two-celled, fixed by their bases, bursting inside; style one; stigma simple or capitate; capsule coriaceous, many-valved, hardly dehiscent; seeds minute, numerous, imbedded in pulp. Composed of usually ascending shrubs with alternate leaves, and umbellate or spicate inflorescence. Distinguished from *Guttiferæ* in the alternate leaves and singular form of the bracteas; it also differs from *Ternstrœmiaceæ* in this last respect. This order is divided into two tribes. Tribe 1. *Marcgravieæ*. Corolla hoodformed; stamens hypogynous. Example, *Marcgravia*. Tribe 2. *Noranteæ*. Corolla of five petals; stamens pressed to the petals, so as to appear inserted into them. Example, *Norantea*.

46. *Hippocrateaceæ*, Kunth.—Sepals generally five, rarely four to six, small and joined to the middle, persistent; petals equal in number to the sepals, with an imbricate æstivation; disk filling the bottom of the calyx, expanding between the petals and the stamens; stamens three, seldom five or ten; anthers one-celled, and bursting transversely, or two to four-celled at the base; ovarium trigonal, hidden within the urceolus or staminiferous baccate tube; style crowned by one to three stigmas; fruit samaroid, capsular, or baccate, one to three-celled; cells usually many-seeded; seeds fixed by pairs to the central axis; albumen none; embryo straight. Composed of arborescent or climbing shrubs, with opposite, entire, or toothed, coriaceous, simple, stipulate leaves, and axillary corymbs or fascicles of insignificant flowers. It differs from the foregoing orders in the singular form of the disk or urceolus, which is either separate from the stamens or formed by the cohesion of the filaments. Examples, *Hippocratea*, *Salacia*.

47. *Erythroxyleæ*, Kunth.—Sepals five, persistent, combined at the base; petals five, each having a scale inside, the margins incumbent in æstivation; stamens ten, monadelphous at the base; anthers versatile, erect, two-celled, bursting lengthwise at the sides; ovary one or three-celled; when the latter number, two of them are empty; ovula solitary, pendulous; styles three, distinct or connected; stigmas three, capitate; drupe containing one angular nut; albumen fleshy or wanting; embryo straight, linear. Composed of trees and shrubs, the branches usually covered with imbricate scales; stipulas axillary, concave; leaves alternate, rarely opposite, entire and smooth; flowers solitary, twin, or in fascicles rising from the axils of stipulaceous scales. This order has been separated from *Malpighiaceæ* on account of the appendiculate petals, albuminous seeds, and one-celled fruit, and peculiar habit. The appendiculate petals and stipulate leaves also separate it from all other orders. The intoxicating *Coco* of Peru is a species of *Erythroxylon*. Examples, *Erythroxylon*, *Sethia*.

48. *Malpighiaceæ*, Jussieu.—Calyx five-parted, usually persistent; petals five, alternating with the lobes of the calyx, unguiculate, sometimes unequal, but seldom wanting; stamens ten, rarely fewer, usually connected at the very base, rarely free; anthers roundish; ovarium three-lobed, composed of three carpels, which are more or less combined; styles three, distinct or connected; fruit of two to three carpels, or of three cells, dry or baccate; cells one-seeded; seeds pendulous; albumen wanting; embryo curved or straight. Composed of shrubs and trees; branches sometimes scandent; leaves opposite, rarely alternate, simple, usually stipulate; flowers disposed in racemes or corymbs; pedicels each furnished with two small scales in the middle. The unguiculate undulated petals readily separate this from all the allied orders. The fruit of some species is edible. The order is divided into two tribes. Tribe 1. *Malpighieæ*. Styles three, distinct or joined; fruit fleshy, indehiscent; leaves opposite. Example, *Malpighia*. Tribe 2. *Hiptageæ*. Style one; carpels dry, indehiscent, one-seeded, usually winged; leaves usually opposite or verticillate. Example, *Hiptage*. Tribe 3. *Banisterieæ*. Styles three, distinct; carpels dry, indehiscent, one-seeded, expanded into wings; leaves opposite, rarely verticillate or alternate.

49. *Acerineæ*, De Candolle.—Flowers unisexual; calyx usually five, rarely four to nine-parted; petals about the same number, alternating with the lobes of the calyx, rarely wanting; stamens usually eight, rarely five to twelve; anthers oblong; ovarium twin; style one; stigmas two; fruit of two indehiscent, samara-like, one-seeded carpels, each ending in a membranous diverging wing, which is thickest on the outer side; seed fixed to the base of the cell; albumen none; embryo curved or convolute. Composed of valuable timber trees, with opposite, usually simple, entire, or lobed leaves. The flowers are disposed in axillary racemes or corymbs. This order is readily distinguished from all its allies by the monoecious, dioecious, or polygamous flowers, which in them are hermaphrodite. The sap of all is saccharine, and from which sugar may be prepared. Examples, *Acer* and *Negundo*.

50. *Hippocastaneæ*, De Candolle.—Calyx five-lobed; petals four or five, unequal; stamens seven to eight, free, unequal; anthers nearly incumbent; style filiform, acute; ovarium three-celled, three-valved; cells two-ovulate, with a dissepiment in the middle of each valve, which the ovula are fixed to; capsule coriaceous, nearly globose, two to three-celled, two to three-valved, two to four-seeded; seeds large, roundish, variously compressed

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and angled, covered with a hard, smooth shell, which is furnished with a broad hilum at the base; albumen wanting; embryo curved, with combined cotyledons. Composed of trees and shrubs, with opposite, palmately compound leaves; leaflets five to seven; racemes panicled, terminal; pedicels jointed. The fruit contains potash and starch; the bark is considered astringent and febrifugal. Examples, *Æsculus*, *Pavia*.

51. *Rhizoboleæ*, De Candolle.—Sepals five, rarely six, connected at the base; petals usually five, unequal, rarely eight, adnate to the stamens at the base; stamens indefinite, disposed in two series, the inner series usually the shortest, with monadelphous filaments and sterile anthers; those of the outer series filiform, with round, fertile anthers; ovarium four-celled, four-seeded; styles four, five, or six; stigmas simple; fruit containing four adglutinated nuts, but generally fewer by abortion; nut indehiscent, one-celled, covered by a hard shell, which is beset with bristles outside; kernels kidney-shaped, keeled, tapering to both ends; albumen wanting; funicle dilated into a two-lobed caruncle; embryo large, edible, the cotyledons lying in the furrow of the radicle. Composed of trees with opposite, stalked, palmate, stipulate, three to five-foliate leaves, and racemes of large bractless flowers. It agrees with *Hippocastaneæ* in the opposite compound leaves, but differs from it in the regular flowers, small cotyledons, and large radicle, which is quite the contrary in *Hippocastaneæ*. The Saouari or Suwarrow and Butter Nuts are the produce of this order. Example, *Caryocar*.

52. *Sapindaceæ*, Jussieu.—Flowers polygamous; male, calyx four to five-parted, or four to five-sepalled, with an imbricate æstivation; petals four to five, rarely wanting, naked or furnished with an appendage each inside, with an imbricate æstivation; disk fleshy, expanded between the petals and stamens; stamens eight to ten, rarely fewer or more, inserted in the disk, or in the receptacle between the glands and the pistil; filaments free or connected at their bases; bermaphrodite flowers same structure as the males; ovarium three-celled, rarely two to four-celled; cells few or many-ovulate; style undivided, or two to three-cleft; ovula erect or ascending, rarely pendulous; fruit capsular, two to three-valved, opening at the dissepiments, sometimes samaroid, and sometimes baccate and indehiscent; seeds usually arillate; albumen wanting; embryo straight, curved or spiral. Composed of trees or shrubs, which are often scandent and furnished with tendrils, with alternate, usually compound, stipulate or exstipulate leaves, which are often marked with pellucid lines or dots; inflorescence racemose or panicled. The petals, being furnished with an additional scale or tuft of hairs inside, distinguish this from other allied orders. Several species of *Nephelium* bear excellent fruit, as the Longan and Lichi of China; the African Akee is the aril of *Blighia*, and the Bully Plum of Jamaica is that of a species of *Melicocca*. The rind of the fruit of several species of *Sapindus* is used instead of soap. The order is divided into two tribes. Tribe 1. *Sapindeæ*. Ovarium containing one ovula in each cell; embryo curved, rarely straight. Examples, *Sapindus*, *Cardiospermum*, *Nephelium*. Tribe 2. *Dodonæaceæ*. Cells of ovarium containing two to three ovula; embryo spiral. Examples, *Kœlreuteria*, *Dodonæa*.

53. *Millingtoniaceæ*, Arnott.—Sepals five, persistent, unequal, with an imbricate æstivation; petals deciduous, the three outer ones orbicular and entire, with an imbricate æstivation, the two inner ones smaller and acutely bifid, resembling scales; stamens five, opposite the petals, slightly united at their very bases, the outer three sterile, and the two inner fertile and opposite the bifid petals; filaments of the fertile stamens flat; cells of anthers globose, dehiscing transversely, placed side by side on the inner side of a saucer-shaped connective; disk flat, thin, hypogynous, free, except at its point of attachment with the ovarium and receptacle; ovarium ovate, two-celled; ovula two in each cell, placed one above another; style short and thick; stigma slightly two-lobed; fruit a one-celled, one-seeded drupe, the dissepiment having disappeared; seed having a small cavity on one side near the base; albumen none, or extremely thin; embryo curved; cotyledons thin, foliaceous, folded; radicle curved, pointing to the hilum. Composed of trees with alternate, exstipulate, entire, simple, rarely pinnate leaves, and terminal, panicled inflorescence; flowers small, inconspicuous, nearly sessile, or on very short pedicels, that are arranged along the horizontal branches of the panicle. Example, *Millingtonia*.

54. *Meliaceæ*, Jussieu.—Calyx four to five-lobed, four to five-cleft, or of four to five sepals; petals four to five, each with a broad claw, connected at their bases, usually with a valvate æstivation; stamens usually twice the number of the petals, rarely more or equal that number; filaments combined into a long, toothed tube; anthers sessile in the throat of the tube, and adnate to its inner side; style one, with distinct or joined stigmas; fruit various, baccate, drupaceous, or capsular, many-celled, but from abortion often only one-celled, but with a dissepiment in the middle of each valve; albumen none; embryo various. This order is composed of large tropical trees, with alternate, exstipulate, usually compound leaves. The filaments being united into a toothed tube, particularly distinguishes this family, which is divided into two tribes. Tribe 1. *Melieæ*. Cells of fruit one to two-seeded; cotyledons flat, foliaceous; leaves simple or compound. Examples, *Melia*, *Turræa*, *Canella*, *Quivisia*. Tribe 2. *Trichilieæ*. Cells of fruit one to two-seeded; cotyledons thick; leaves pinnate and trifoliate, rarely simple. Examples, *Trichilia*, *Guarea*.

55. *Cedrelaceæ*, R. Brown.—This order principally differs from the last, of which it is probably only a tribe, in the stamens being inserted on the torus, or protruding from the back of the urceolus, rarely fixed to the throat of the stamineous tube, as in *Swietenia*, and in the seeds being winged and albuminous. The order contains large trees, with dense, beautifully grained, coloured, sweet-scented wood, alternate, impari-pinnate leaves, and large spreading pyramidal panicles, composed of little cymes of flowers. The Mahogany, Satinwood, and West India Cedar are of this order.

56. *Humiriaceæ*, St. Hilaire.—Calyx five-cleft; petals five, alternating with the lobes of the calyx; stamens numerous, monadelphous at their bases, and having the filaments drawn out beyond the anthers, which are short, and two-celled; style one, crowned by a lobed stigma; ovarium free and usually girded by an annular disk at the base, five-celled; fruit drupe-formed, containing a nut of five or fewer cells; cells one to two-seeded; embryo straight, oblong; albumen fleshy. An order composed of tropical trees and shrubs, abounding in resinous juice, with alternate, simple, coriaceous, exstipulate leaves, and axillary corymbs of flowers. Examples, *Humirium*, *Helleria*.



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57. *Ampelideæ*, Kunth.—Calyx small, entire, or toothed; petals four or five, alternating with the teeth of the calyx, broadest at their bases, rarely gamopetalous, valvate and inflexed at tops in æstivation; stamens four or five, free or combined; anthers birimose, oscillatory; style short; stigma simple; berry globose, two-celled, cells two-seeded, but one-celled in the adult state from the dissepiment having vanished, not separable from the epicarp; seeds four to five, or fewer from abortion, bony, fixed to the central placenta by funicles; albumen fleshy; embryo erect. This order is composed of sarmentose or climbing shrubs, having the lower leaves opposite, and the upper ones alternate; they are stalked, simple, lobed, or compound, furnished with stipulas at their bases; peduncles racemose, thyrsoid, corymbose, or cymose opposite the upper leaves, often changed into tendrils; flowers insignificant. The Vine is of this order, and the common grape is the only species that bears really good fruit, the American kinds being spoiled by a foxy flavour. This family is divided into two tribes. Tribe 1. *Viniferæ*. Corolla polypetalous. Examples, *Vitis*, *Ampelopsis*, *Cissus*. Tribe 2. *Leeaceæ*. Corolla gamopetalous. Example, *Leea*.

58. *Geraniaceæ*, De Candolle.—Sepals five, unequal, rarely joined, sometimes one of them is drawn out into a hollow spur at the base, which is closely combined within the peduncle, with an imbricate æstivation; petals five, rarely four, unguiculate, equal or unequal; stamens rarely free, but usually monadelphous at their bases, hypogynous or perigynous, five or more, some of them often sterile; ovarium five-celled, ending in a long thick style, which is crowned by five stigmas; carpels five, indehiscent, one-celled, biovulate, each ending in a style or awn, which at first closely adheres to the torus, but at maturity the awns separate and become twisted in various ways from their bases to their apices at maturity, and by their elasticity separate the carpels from the torus; carpels one-seeded; albumen none; embryo curved. This order is composed of herbs or soft-stemmed shrubs, having the young branches jointed at the nodi and separable as in *Ampelideæ*; the lower leaves are opposite and the upper ones alternate, with the peduncles opposite them, as in *Ampelideæ*; flowers of various hues, solitary or umbellate. Astringency is the principal property of this family. It is readily distinguished by the separating of the carpels from the torus by the elastic nature of the styles. Examples, *Pelargonium*, *Geranium*, *Erodium*, and *Monsonia*.

59. *Limnantheæ*, R. Brown.—Flowers regular; calyx of three to five sepals, persistent, with a valvate æstivation; petals three to five, marcescent; stamens six to ten, with an ambiguous insertion between hypogynous and perigynous; filaments distinct, the three or five which are opposite the sepals furnished each with a gland outside at the base; ovaria two to five, opposite the sepals, connected with the base of the style, which is gynobasic, one-seeded; ovulum erect, with an inverted nucleus; style two to five-cleft at apex; achenia rather fleshy; albumen none; embryo straight; radicle inferior. Composed of marsh, annual, glabrous herbs, natives of North America, with alternate, exstipulate, dissected leaves, and one-flowered bractless peduncles, which are dilated at their apices, and there resembling turbinate bases to the calyxes. The order appears to be intermediate between *Geraniaceæ* and *Tropæoleæ*.

60. *Tropæoleæ*, Jussieu.—Calyx coloured, five-parted, upper segment drawn out into a spur at the base; lobes free, or more or less joined; petals five, inserted in the calyx, unequal, the two upper ones sessile and remote, fixed to the mouth of the spur, the three lower ones unguiculate and smaller, and sometimes abortive; stamens eight, free; anthers terminal, erect, two-celled, bursting by double chinks; styles three, joined; carpels three, adnate to the bases of the styles, one-celled, one-seeded; seeds large; albumen none; embryo large. Composed of American, usually trailing or scandent herbs having a hot taste, with alternate, peltate, lobed or five to seven-parted leaves, and axillary one-flowered peduncles. This is the only family having the peculiar acrid flavour of Cresses or *Cruciferæ*, and is powerfully antiscorbutic like them; the flowers are handsome. The structure of the fruit and seeds, the axillary peduncles, and free stamens, distinguish it from *Geraniaceæ*. Example, *Tropæolum*.



61. *Balsamineæ*, A. Richard.—Sepals two, small, deciduous, opposite, with an imbricate æstivation; petals four, cruciate, the two outer ones ending in a callous tip each, the upper one arched and emarginate, and the lower one entire and drawn out into a spur at the base, the two inner ones usually bifid or appendiculate; stamens five, on short filaments, which are thickened at their apices; anthers rather connate, bursting lengthwise, the three lower ones two-celled and opposite the petals, the two upper ones one-celled, seldom two-celled, arising in front of the upper petal; style none; stigmas five, distinct, or connected; capsule oblong or ovate, five-valved; valves separating with elasticity; placenta central, with five membranous, intervalvular angles, therefore the capsule is five-celled at the base, but only one-celled above the placenta; seeds numerous, pendulous; albumen none; embryo straight. Composed of tender, usually annual, succulent herbs, with alternate or opposite, serrated leaves without stipulas, and axillary one or few-flowered peduncles; flowers singular as well as varied in colour. The well-known elastic spring with which the seeds are ejected, as in Tooch-me-not, *Impatiens*, constitutes the principal character of this order. M. De Candolle remarks, that the flowers are those of *Fumariaceæ*, the capsules of *Oxalis*, the seeds of *Linum*, and the habit peculiar. Examples, *Impatiens*, *Balsamina*.

62. *Hydrocereæ*, Blume. Calyx of five deciduous, unequal, coloured sepals, of which the lowermost one is spurred, with an imbricate æstivation; petals five, unequal, the upper one arched; stamens five, connate at their apices; anthers slightly connate, bilocular, dehiscing at their apices, ovarium five-celled; ovula pendulous, two to three in each cell; stigmas five, sessile, acute; fruit juicy or baccate, five-celled; endocarp hard and bony; seed solitary; albumen none; radicle next the hilum; cotyledons plano-convex. Composed of aquatic, floating, or marsh herbs, with simple, alternate, exstipulate leaves, axillary, solitary, gaudy flowers, and baccate fruit. This order differs principally from *Balsamineæ* in the structure and substance of the fruit. Example, *Hydrocera*.

63. *Oxalideæ*, De Candolle.—Calyx five-sepalled or five-parted, equal, persistent; petals five, unguiculate, with a spirally-twisted æstivation; stamens usually monadelphous at their bases, inner ones the longest; anthers two-celled, not adnate; styles five, filiform, variable in length compared with the stamens; stigmas usually pencil-formed, also capitate, and sometimes bifid; capsule pentagonal, five-celled, five to ten-valved; seeds few, inclosed in fleshy arils, which at length burst

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in an elastic manner at their apices; albumen cartilaginously fleshy; embryo inverted. This order is composed usually of herbs with generally bulbo-tuberous roots, rarely of subshrubs or trees; leaves alternate, rarely opposite or in whorls, simple, or variously compounded. The arillate elastic seeds and structure of the flowers are sufficient to distinguish this order. All the species are acid, which depends upon the presence of a small quantity of oxalate of potass. In some South American species oxalic acid exists in great abundance. Examples, *Oxalis, Averrhoa.*

64. *Zygophylleæ*, R. Brown.—Sepals five, seldom connected at their bases; petals five; stamens ten, distinct; ovarium single, five-celled; styles five, connected into one, or distinct at their apices; carpels five, more or less connected, dehiscing at the upper angle, many-seeded, seldom only one-seeded; albumen present or wanting; embryo straight. Composed of herbs, shrubs, and trees of variable habit; leaves furnished with stipulas at the base, usually compound, in the true *Zygophylleæ* opposite, but in the spurious *Zygophylleæ* alternate. This family is intermediate between *Oxalideæ* and *Rutaceæ:* it is distinguished from the first in the styles being joined, and by the exarillate seeds, as well as by the opposite stipulate leaves, and from the last in the structure of the carpels, and the absence of elastic cocculum. They are more readily distinguished from both these orders in the twin stipulas at the bases of the petioles. *Zygophyllum-Fabago* is employed as an anthelmintic. *Guaiacum* is also the produce of this order. Examples, *Tribulus, Fagonia, Zygophyllum, Guaiacum, Melianthus.*

65. *Rutaceæ*, Jussieu.—Flowers usually hermaphrodite, seldom unisexual; calyx three, four, or five-toothed, cleft or parted; petals equal in number to the divisions or teeth of the calyx, usually distinct, rarely gamopetalous or absent; stamens the same number as the petals, or double that number, hypogynous and perigynous; filaments free, rarely connected, naked, or furnished with a scale each inside, glued to the corolla when monopetalous; anthers two-celled, bursting lengthwise; ovarium with as many cells as there are petals; styles equal in number to the cells of the ovarium, more or less connected; stigmas equal in number; fruit sometimes simple, with a dissepiment in the middle of each valve, dehiscent, but more usually of an equal number of two-valved separable carpels, rarely indehiscent, and composed of many drupes or carpels; seeds furnished with a two-valved elastic cocculum, usually two in each cell; albumen fleshy or horny, rarely wanting. This order contains an interesting and extensive but heterogeneous group of plants, natives of all countries and all situations. They are either fetid, herbaceous plants, as the Rue, or heath-like shrubs, as *Diosma*, or broad and long-leaved shrubs, as *Corræa, Eriostemon*, and *Crowea*, or trees, as *Zanthoxylum, Cusparia.* The medical properties are considerable; *Ruta* is anthelmintic and emmenagogue; *Brucea* is used as an astringent in dysenteries; *Galipea* is the famous Angustura bark, used as a febrifuge. The leaves are opposite or alternate, simple or compound, but always without stipulas, which distinguishes it from the last order and *Simarubeæ;* they have usually glands which contain oil of a strong scented odour. The family is divided into seven different tribes, which have been considered by some botanists to constitute as many different orders. Tribe 1. *Ruteæ.* Flowers regular; stamens hypogynous; calyx four to five-cleft; petals four to five; albumen fleshy. Leaves alternate, simple, or compound. Examples, *Ruta, Peganum.* Tribe 2. *Diosmeæ-Europæanæ.* Flowers irregular; stamens hypogynous; disk wanting; ovaries five, distinct; albumen fleshy. Example *Dictamnus.* Tribe 3. *Diosmeæ-Capenses.* Flowers regular; calyx five-parted; petals five; disk present; stamens five, perigynous; ovaries one to five, connected; albumen thin or wanting. Examples, *Diosma, Agathosma, Empleurum.* Tribe 4. *Diosmeæ-Australacicæ.* Flowers regular; petals four to five; stamens eight to ten, hypogynous; disk wanting; ovaries distinct or connected; styles joined; albumen dense. Examples, *Corræa, Phebalium, Crowea, Borronia, Zieria.* Tribe 5. *Diosmeæ-Americanæ.* Flowers regular; petals free; disk present or wanting; styles connected; albumen fleshy, rarely wanting; leaves opposite or alternate, simple, bifoliate or trifoliate; shrubs and trees. Examples, *Evodia, Choisya.* Tribe 6. *Cusparieæ.* Flowers regular or anomalous; petals free or combined into a bilabiate or funnel-shaped corolla; stamens free, or adhering to the corolla, and sometimes some of them are sterile; styles connected at top or bottom, but usually in one; disk urceolate, girding the ovaries; albumen wanting. Composed usually of trees and shrubs with alternate, simple, or trifoliate leaves. Examples, *Galipea, Spiranthera.* Tribe 7. *Zanthoxyleæ.* This differs from *Cusparieæ* in the flowers being unisexual. Examples, *Brucea, Ailantus, Zanthoxylum.*

66. *Simarubeæ*, Richard.—Flowers hermaphrodite, rarely unisexual; calyx persistent, of four to five sepals, which are scarcely connected at their bases; petals four to five, sometimes conniving into a tube, with a twisted æstivation, caducous; stamens eight to ten, each rising from the back of a hairy, hypogynous scale; anthers birimose; styles four to five, connected; stigma four to five-lobed; drupes four to five, or fewer by abortion, indehiscent; seeds pendulous, solitary; albumen none. Composed of trees and shrubs, with alternate, usually pinnate, rarely simple, leaves, without stipulas; peduncles axillary and terminal, bearing racemose or umbellate inflorescence. This family differs from *Rutaceæ* in the albumen being wanting, in the radicle being retracted between the thick cotyledons, and in the ovaries containing only one ovulum; and from *Ochnaceæ* in the dehiscence of the anthers. The property of this order is a powerful bitter; the *Quassia* and *Simaruba* belong to it, well known as the most powerful bitters hitherto discovered. Examples, *Quassia, Simaruba, Simaba.*

67. *Dipterocarpeæ*, Blume.—Sepals five, usually connected at their bases, with a valvate or imbricate æstivation; petals five, joined into a subrotate corolla, with a twisted æstivation; stamens usually indefinite, free, or connected a little at their bases, sometimes irregularly polyadelphous; anthers erect, elongated, awl-shaped, two-celled, bursting at their apices by two pores; ovarium few-celled; cells biovulate; style undivided; stigma simple; fruit girded by a thick corticate pericarp, and by a more or less extended calyx, one-celled, one-seeded by abortion, three-valved, indehiscent; albumen wanting; embryo chrysalis-like. Composed of tall, elegant trees, full of a resinous turbid juice, with alternate entire leaves, which are involute before expansion, and oblong, convolute, deciduous stipulas, like that of *Ficus;* the branches are therefore terminated by a conical acumen, which at length divides and falls off;



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peduncles racemose, axillary near the taps of the branches, constituting terminal panicles. This order agrees with the next in the anthers being terminated each by a beak, and opening by two pores, by the unilocular fruit, by the absence of albumen, and by their alternate leaves furnished with membranous caducous stipulas. The order is remarkable as containing the Campbor-tree of Sumatra, and many others of the species produce Camphor, although of an inferior quality. The Indian Gum Copal is also the produce of this order. Examples, *Dipterocarpus, Shorea, Dryobalanops, Vateria.*

Fourth cohort. Fruit gynobasic, inserted in a fleshy receptacle, with which the style is continuous.

68. *Ochnaceæ*, De Candolle.—Sepals five, scarcely connected at their bases, persistent, with an imbricate æstivation; petals five, rarely ten, caducous, with an imbricate æstivation; stamens five to ten, or indefinite; anthers bilocular, inserted by their bases; ovaries equal in number to the petals; style filiform, persistent, widened at base, and bearing the ovaries on the subglobose fleshy disk called the gynobase; carpels somewhat drupaceous, one-seeded, indehiscent, inserted in a whorl round the base of the style; albumen none; embryo straight. Composed of tropical trees or shrubs with alternate, simple, entire, or toothed leaves, furnished each with two caducous stipulas at the base; flowers racemose, usually yellow, lateral, axillary, and terminal. The root of *Walkeria* is used in decoction as a tonic, stomachic, stimulant, and anti-emetic. Examples, *Ochna, Gomphia.*

69. *Coriarieæ*, De Candolle.—Flowers hermaphrodite or unisexual; calyx or perigone of one campanulate, ten-cleft sepal; the five outer lobes are ovate, and larger than the five inner ones, which are callous; petals wanting; stamens ten, filiform, hypogynous, opposite the lobes of the calyx; anthers two-celled, oblong; ovarium seated on a thickish torus, five-angled, five-celled; style none; stigmas five, long, awl-shaped from the top of the ovarium; carpels five, nearly free at maturity, approximate, indehiscent, one-seeded, surrounded by large glandular lobes; seed pendulous; albumen wanting; embryo straight. Composed of shrubs with tetragonal, opposite, or tern branches, and opposite, simple, three-nerved, entire, ovate, or cordate leaves, scaly leaf-buds, and terminal simple racemes of small flowers. The real station of this order in the natural system is doubtful. Astringency is its property. *Coriaria myrtifolia* is used for tanning leather, and also in dyeing black colours.

Second subclass. *Calyciflora*, De Candolle.—Calyx gamosepalous, that is the sepals are more or less connected, especially at their bases; torus or receptacle more or less adnate with the inside of the calyx at the base; petals and stamens inserted in the calyx, or in that part of the torus which is adnate to the calyx, and therefore rising from the calyx; petals usually free, but sometimes the corolla is gamopetalous; ovarium free, or adnate to the calyx; the fruit is therefore either inferior or superior. The torus or disk in *Calyciflora* appears to be a dilatation of the peduncle converted into petals and stamens; it is large and adnate to the calyx, usually bearing the petals and stamens, but sometimes it girds the stipe of the ovarium, as in *Passiflora* and the greater part of *Leguminosæ*. The petals and stamens are, however, for the most part inserted in the calyx, which distinguishes the plants of this subclass from those of *Thalamifloræ*, as also in the torus of that subclass neither adhering to the calyx nor to the ovaries.

First division. *Peripetalæ*, Jussieu. Petals and stamens inserted in the calyx, that is perigynous.



70. *Stackhousieæ*, R. Brown.—Calyx five-cleft, tube inflated; petals five, inserted in the top of the calycine tube, combined by the claws at their bases into a tube; limb spreading; stamens five, unequal, rising from the throat of the calyx; ovarium superior, three to five-lobed; ovule solitary, erect; styles three to five, usually united at their bases; stigmas simple; fruit of three to five, indehiscent, winged or wingless carpels, attached to a central, persistent column; albumen fleshy; embryo erect. Composed of shrubs with simple, entire, alternate leaves, furnished with lateral minute stipulas. This order is considered more nearly related to *Celastrineæ* than to any other. Example, *Stackhousia.*

71. *Celastrineæ*, R. Brown.—Sepals four to five, obtuse, connected at their bases with an imbricate æstivation; petals four to five, flat, broadest at their bases, fixed under the margin of the disk, with an imbricate æstivation; stamens four to five, alternating with the petals, inserted in the disk; anthers two-celled, bursting inwards; disk large; ovarium free, immersed in the disk, and adnate to it, two to four-celled; cells one-ovulate; fruit free, two to four-valved, two to four-celled; capsule with a dissepiment in the middle of each valve, or a dry drupe, containing a two-celled two or many seeded nut; albumen fleshy; embryo straight. Composed of shrubs and trees with alternate or opposite, simple, rarely compound, usually stipulate leaves, and axillary cymes of flowers. *Euonymus Europæus* is purgative and emetic. This order is distinguished from the next in the stamens alternating with the petals, and by the imbricate æstivation of the calyx, flat petals, and superior ovarium. It is separated into three tribes. Tribe 1. *Staphyleaceæ*. Seed bony, without aril, truncate at the hilum; albumen wanting; leaves pinnate or trifoliate. Example, *Staphylea*. Tribe 2. *Euonymeæ*. Seeds arillate; albumen fleshy; leaves simple. Examples, *Euonymus, Celastrus, Maytenus*. Tribe 3. *Cassineæ*. Fruit indehiscent or drupaceous; albumen fleshy; leaves simple. Examples, *Cassine, Curtisia.*

72. *Rhamneæ*, R. Brown.—Calyx four to five-cleft, the tube adhering to the base of the ovarium, with a valvate æstivation; petals four to five, cucullate or convolute, rarely wanting, often scale-formed, always in the mouth of the calyx; stamens four to five, opposite the petals; anthers one or two-celled; ovarium free, or adhering to the calyx more or less, always immersed in the disk when there is any, two to three, rarely four-celled; cells one-seeded; styles one to three; stigmas two or three; fruit fleshy, indehiscent, or dry and tricoccous; seeds erect; albumen fleshy, rarely wanting; embryo straight. Composed of trees and shrubs with simple, alternate, rarely opposite leaves, which are usually furnished with stipulas, and small flowers. Nearly allied to *Celastrineæ*, but differs in the valvate æstivation of the calyx, cucullate petals, in the stamens being opposite the petals, and in the ovarium being more or less adnate to the calyx at the base. The properties of the plants of this order are purgative and emetic, as *Rhamnus*, the Buckthorn. *Zizyphus* bears edible fruit, as the African Lotos and Italian Jujube. The berries of a great number yield a yellow dye, as the Avignon berries. Examples, *Rhamnus, Zizyphus, Paliurus, Hovenia, Pomaderris, Phylica.*

73. *Terebinthaceæ*, Jussieu.—Flowers generally unisexual; calyx small, persistent, usually of five divisions,

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rarely of three, four, or seven; petals equal in number to the divisions of the calyx, perigynous; stamens perigynous, the same number, or twice that number, equal or unequal, and sometimes some of them are sterile; filaments usually distinct, but in general, where there is no calycine disk, cohering at their bases; disk, when present, fleshy, annular, or cup-shaped; ovarium usually solitary, rarely five or six, of which four or five become abortive, usually superior, rarely inferior; styles one to three, and sometimes four, and sometimes wanting; stigmas the same number; ovulum solitary, attached by a funicle to the bottom of the cell; fruit indehiscent; albumen none; embryo with the radicle directed to the hilum. Composed of trees and shrubs full of resinous, gummy, caustic, highly poisonous juice; leaves alternate, simple, ternate or pinnate; flowers terminal or axillary. The juice of several species is used as black varnish. The Cashew and Pistachio are valuable for their nuts; and the Mango for its fruit. Mastich and Venetian turpentine are the produce of two species of *Pistacia*. The bark of *Rhus coriaria* is used in tanning leather, and *Rhus caustica* and others are extremely poisonous. This order is divided into two tribes. Tribe 1. *Anacardieæ*. Cotyledons thick, replicate above the radicle. Examples, *Anacardium*, *Semicarpus*, *Mangifera*, *Pistacia*. Tribe 2. *Sumachineæ*. Cotyledons foliaceous, having the radicle bent above them. Examples, *Rhus*, *Duvaua*, *Schinus*.

74. *Spondiaceæ*, Kunth.—Flowers usually unisexual; calyx five-cleft, persistent or deciduous; petals five, inserted below the disk, with a valvate or imbricate æstivation; stamens ten, perigynous, inserted with the petals; disk annular in the male flower, orbicular, and ten-toothed; ovarium superior, two to five-celled; ovula one in each cell, pendulous; styles five, short, crowned by as many obtuse stigmas; fruit drupaceous, containing a two to five-celled nut; albumen none; radicle pointing towards the hilum, inferior. Composed of trees with unequally pinnate leaves, having a few simple ones now and then intermixed, all without stipulas, and axillary and terminal flowers disposed in panicles or racemes. Nearly allied to *Terebinthaceæ*, but is distinguished by the absence of resinous juice; the fruit is almost that of *Mangifera*, but is compound and not simple as in that genus. The fruit of all the species are estable, and are known by the name of Plums within the tropics. Examples, *Spondias*, *Pourpartia*.

75. *Burseriaceæ*, Kunth.—Flowers generally hermaphrodite, rarely unisexual; calyx persistent, almost regular, of two to five divisions; petals three to five, rising from the calyx below the disk, with a valvate æstivation; stamens from two to four times as many as there are petals, perigynous; disk orbicular or annular; ovarium two to four-celled, superior sessile; style short or wanting; stigmas equal in number to the cells of the ovarium; ovula in pairs attached to the axis; fruit drupaceous, two to five-celled, having the outer part often splitting into valves; albumen none; radicle superior, turned to the hilum. Composed of trees or shrubs abounding in balsamic resin or gum, with alternate, unequally pinnate leaves, which are occasionally stipulate, and axillary and terminal flowers, which are disposed in racemes or panicles. Closely allied to *Terebinthaceæ*, from which it principally differs in the compound fruit, and in the fragrant, resinous juice, which is caustic in that order. Olibanum, or the frankincense of the ancients, is the juice of *Boswellia serrata*. Gum Elemi is the produce of a species of *Icica*. The nuts of *Canarium commune* are eaten in Java. Examples, *Boswellia*, *Bursera*, *Garuga*, *Elaphrum*.

76. *Amyrideæ*, R. Brown.—Calyx small, persistent, of four to five divisions; petals four to six, hypogynous, with an imbricate æstivation; stamens eight to twelve, also hypogynous; ovarium superior, one-celled, seated on a thickened disk, containing a single pendulous ovulum; stigma sessile, capitate; fruit indehiscent, rather drupaceous, glandular; albumen none; radicle short, superior; cotyledons fleshy. Composed of trees abounding in resinous fragrant juice, with opposite compound leaves, full of pellucid dots, and axillary and terminal panicles of flowers. The pericarp is covered by granular glands filled with aromatic oil. This order is nearly allied to the three preceding, but differs from them in the leaves being full of dots filled with resinous oil, and in the hypogynous insertion of the petals and stamens, and on these accounts agrees better with *Aurantiaceæ*. The Gum Elemi of the Island of Nevis is the produce *Amyris hexandra*. The Gum Resin called Bdellium is probably the produce of another species of *Amyris*, and the Resin of Coumia is that of *Amyris ambrosiaca*. The inner bark or liber of a species of the same genus is used by Nubian Mahommedans as paper, on which they write their legends. The fruit of *Pachylobus* is eaten by the natives of Africa under the name of Safu. Example, *Amyris*.

77. *Connaraceæ*, Kunth.—Flowers hermaphrodite, rarely unisexual; calyx regular, five-parted, persistent, with an imbricate or valvular æstivation; petals five, inserted in the calyx, with an imbricate, rarely valvular æstivation; stamens ten, hypogynous, unequal, usually monadelphous at their bases; ovarium solitary or several together, each having a distinct style and a usually dilated stigma; ovula two in each ovary, collateral, ascending; capsules generally several, splitting lengthwise inside; seeds erect by pairs, usually furnished with aril; albumen present or wanting; radicle superior; cotyledons thick or foliaceous, just as the albumen is wanting or present. Composed of trees or shrubs, with compound, alternate, exstipulate leaves, full of dots, and terminal racemes or panicles of bracteate flowers. This order can only be distinguished from *Leguminosæ* by the radicle being at the extremity of the seed, most remote from the hilum. The want of stipulas to the leaves is usually sufficient to distinguish them. Examples, *Connaris*, *Cnestis*.

78. *Leguminosæ*, Jussieu.—Calyx five-cleft or five-toothed, sometimes bilabiate; petals usually five, rarely fewer, papilionaceous or unequal, rarely nearly equal, inserted in the bottom of the calyx, rarely in the torus, imbricate in various ways in æstivation, rarely valvate, usually free, rarely combined; stamens inserted with the petals, and generally twice their number, rarely more or less, free, monadelphous or diadelphous; anthers two-celled; ovarium sessile or stipitate, free, rarely having the stipe adnate to the calyx; style filiform; stigma terminal or lateral; legume usually two-valved, rarely fleshy, one-celled, rarely two-celled, often transversely many-celled, and separating into one-celled joints; seeds generally numerous, fixed to the upper suture of the legume by a funicle each, rarely expanded into aril; endopleura tumid; albumen none; radicle always directed to the hilum. Composed of trees, shrubs, and herbs diffused throughout the world, variable in habit; leaves usually alternate, simple, pinnate, bipinnate, su-

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pinnate, petiolate, bistipulate, petioles having two callosities at their bases, sometimes flattened in the form of leaves which are called phyllodia, as in various species of New Holland Acacia; flowers of various hues, axillary or terminal, disposed in racemes or panicles, rarely solitary. The various kinds of pulse belong to this family, as Peas and Beans, &c., and the greater number are objects of ornament. The papilionaceous flowers characterise a great number, and the pea-pods or legumes the rest. The bark is bitter, and contains a considerable portion of tannin. Indigo, Brasiletto, Gum Lac, Balsam of Tolu, Balsam of Peru, Balsam of Copivi, Gum Arabic, Gum Tragacanth, Manna of the ancients, Logwood, Tonquin Bean, and many other drugs, are the produce of this family. The order is separated into numerous suborders, tribes, and subtribes, viz.: Division 1. *Curvembriæ*. Radicle bent back upon the edge of the lobes of the cotyledons in the embryo. Suborder 1. *Papilionaceæ*. Corolla papilionaceous. Sec. 1. *Phyllolobæ*. Cotyledons thin, leafy; pulse not edible. This is divided into the following tribes. Tribe 1. *Sophoreæ*; 2. *Loteæ*; 3. *Hedysareæ*. Examples, *Sophora*, *Podolobium*; *Hovea*, *Cytisus*, *Lotus*, *Trifolium*, *Psoralea*, *Robinia*, *Colutea*, *Astragalus*; *Coronilla*, *Hedysarum*, *Alhagi*. Sec. 2. *Sarcolobæ*. Embryo with thick fleshy cotyledons; pulse edible. This is divided into the following tribes. Tribe 4. *Vicieæ*; 5. *Phaseoleæ*; 6. *Dalbergieæ*. Examples, *Vicia*, *Pisum*; *Phaseolus*, *Lupinus*, *Erythrina*; *Dalbergia*. Suborder 2. *Swartzieæ*. Calyx ruptured valvately; petals few, irregular, or wanting, hypogynous as well as the stamens; cotyledons thick. Example, *Swartzia*. Division 2. *Rectembriæ*. Radicle and cotyledons straight. Suborder 3. *Mimoseæ*. Flowers regular, usually polygamous; petals four to five, equal, with a valvate æstivation, usually hypogynous like the stamens; cotyledons usually foliaceous. Examples, *Mimosa*, *Acacia*, *Inga*. Suborder 4. *Cæsalpineæ*. Flowers more or less irregular, rarely subpapilionaceous, but generally regular, with an imbricate æstivation; stamens perigynous, usually free. This suborder is divided into three tribes. Tribe 9. *Geoffreæ*; 10. *Cassieæ*; 11. *Detarieæ*. Examples, *Arachis*, *Geoffroya*, *Dipterix*; *Cassia*; *Detarium*.

79. *Moringeæ*, R. Brown.—Calyx five-parted, with a slightly imbricate æstivation; petals five, nearly equal, upper ones ascending; stamens ten, perigynous; filaments flattened, callous, and hairy at their bases; anthers one-celled, each with a thick convex connective; torus or disk fleshy, lining the tube of the calyx; ovarium superior, stipitate, one-celled; style filiform, terminal; stigma simple; fruit a legume-like, one-celled, three-valved capsule, with a loculicidal dehiscence, and a parietal placenta in the middle of each valve; seeds numerous, half buried in the spongy substance of the valves; albumen none; radicle straight, small; cotyledons fleshy, plano-convex. Composed of trees with bi or tripinnate leaves. Separated from *Leguminosæ* on account of the very different structure of the fruit. The root of *Moringa hyperanthera*, or Horseradish tree, has a warm, biting, aromatic taste, and is used as a stimulant in paralytic affections and intermittent fevers. Example, *Moringa*.

80. *Chrysobalaneæ*, R. Brown.—Flowers more or less irregular; calyx five-lobed, persistent; petals five, inserted in the calyx, with an imbricate æstivation; stamens usually numerous, seldom few, inserted with the petals, curved before expansion; anthers two-celled, bursting by double chinks; ovarium single, superior, containing two erect ovula, the style issuing from its base on one side; style simple; stigma more or less dilated; seed generally solitary by abortion; albumen wanting, except in the genus *Hirtella*, in which it is fleshy, and the cotyledons foliaceous; embryo erect. Composed of trees and shrubs, with entire petiolate leaves, and axillary and terminal racemes or panicles of flowers. The fruit of many of the order are eatable, although dry and farinaceous, and go under the name of Plums in the places of their natural growth. The position of the style distinguishes this family from all others. The irregularity of the flowers consists in the cohesion of the stipe of the ovarium with one side of the calyx, and a greater number and greater perfection of stamina on the same side of the flower. Examples, *Chrysobalanus*, *Parinarium*, *Hirtella*.

81. *Amygdalaceæ*, Jussieu.—Calyx five-toothed, deciduous, lined by the disk, the fifth lobe superior; petals five, perigynous; stamens numerous, inserted in the throat of the calyx, curved inwards in æstivation; anthers innate, one-celled, bursting lengthwise; ovarium superior, solitary, containing two suspended ovula; style terminal, having a furrow on one side, terminated by a reniform stigma; seed usually solitary by abortion; embryo straight, with the radicle pointing to the hilum; albumen none. Composed of trees and shrubs, with simple, alternate, serrated leaves, which are generally glandular towards their bases; stipulas simple, generally glandular. The order is distinguished from the following by its fruit being a superior drupe, and by the presence of prussic acid, as well as by the drupaceous fruit from *Leguminosæ*. The fruit of all are edible, as *Amygdalus*, the Almond, *Persica*, the Peach, *Armeniaca*, the Apricot, *Prunus*, the Plum, and *Cerasus*, the Cherry. A variety of *Cerasus avium* is used for the preparation of the liquor called Kirschenwaesser. The kernel of *Cerasus occidentalis* is used for flavouring noyeau. The prunes of the shops are prepared from several kinds of plums.

82. *Spiræaceæ*, G. Don.—Calyx five-cleft, with an imbricate æstivation the fifth lobe superior; disk lining the tube or surrounding the orifice; petals five, equal, perigynous; stamens numerous, rising with the petals from the disk or the calyx, curved inwards in æstivation; anthers innate, two-celled, bursting lengthwise; ovula pendulous; follicles or carpels several, superior, distinct, free, disposed in a whorl, but often fewer by abortion, splitting inwardly, sometimes two-valved; seeds usually two to four in each carpel, seldom solitary by abortion; cotyledons flat, thickish. Composed of shrubs or herbs, with alternate, simple, trifoliate or pinnate leaves; roots of all so astringent as to be used for tanning, and the roots of *Gillenia*, in addition to its astringency, has an emetic property. This is distinguished from the neighbouring families in the numerous dehiscent, follicular carpels, and from *Rosaceæ* in the styles being terminal. Examples, *Purshia*, *Kerria*, *Spiræa*, and *Gillenia*.

83. *Quillajeæ*, D. Don.—Calyx five-cleft, with a valvate æstivation; petals five or wanting, perigynous; stamens ten to fifteen, perigynous; anthers two-celled; ovaries five, combined at the base, one-celled, containing numerous erect ovula; stigmas unilateral, papillous; follicles five, disposed in a circle, joined at their bases, seeds disposed in two rows, inserted on the inner suture of the follicles, ascending, winged at their apices, having

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the umbilicus at the base; albumen wanting; embryo erect, with foliaceous, convolute cotyledons, the radicle pointing to the umbilicus. Composed of South American trees, with simple, alternate leaves, small caducous stipulas, and terminal, dioecious flowers. This order differs from *Rosaceæ* and *Spiræaceæ* in the erect ovula, and from the latter in the valvular æstivation of the calyx. The habit of the trees is also different. Examples, *Quillaja, Kageneckia*.

84. *Potentillaceæ*, Jussieu; *Fragariaceæ*, Rich.; *Rosaceæ*, tribe *Dryadeæ*, Vent.—Calyx usually ten-cleft, rarely eight-cleft or many-parted, with a valvate æstivation, the outer segments accessory, and alternating with the inner ones. Petals four to five, rarely more; stamens numerous, inserted in the top of the tube of the calyx; anthers innate, two-celled; ovaries superior, several one-celled, one-seeded; ovula usually suspended; styles unilateral near the apices of the ovaries, with a furrow on one side; stigmas simple or emarginate, oblique; carpels or achenia numerous, crowded, rarely few, inserted on an elevated, usually conical, spongy, or fleshy torus, free from each other and from the calyx, bearing each a style on one side near the apex; achenia dry or baccate, one-seeded; seed erect or inverted; albumen none; embryo erect, with flattish cotyledons; radicle pointing to the hilum. Composed of herbs or small shrubs with a peculiar habit; leaves alternate, usually compound, but often simple, lobed, or serrated, furnished each with two stipulas, which are adnate to the sides of the petioles. This order differs from its allies in the numerous segments of the calyx and their valvular æstivation, and in the numerous one-seeded carpels which are seated on an elevated torus, and in the style proceeding from the side near the apex. Astringency is the property of this family. The fruit of many kinds are edible, as *Rubus*, the Bramble, *Fragaria*, the Strawberry, *Rubus*, the Raspberry and Cloudberry. *Brayera* is considered one of the most powerful anthelmintics known Examples, *Dryas, Geum, Rubus, Fragaria, Potentilla, Comarum, Sibbaldia, Agrimonia*.

85. *Rosaceæ*, Jussieu.—Calyx having the tube contracted at the mouth; limb five-parted, spirally imbricate at the apex in æstivation; segments usually pinnately divided; petals five, equal, perigynous; stamens numerous, rising from the calyx just within the petals; anthers innate, two-celled; ovaries numerous, one-celled, one-seeded, inserted on the inside of the tube of the calyx, which at length becomes baccate, and incloses them; they are dry and indehiscent, each furnished with a style on the inner side, and which protrude from the constricted part of the tube of the calyx; they are generally distinct, seldom joined into a column, as in *Rosa arvensis*; stigmas oblique; carpels numerous, bony on the inside of the tube of the calyx, one-seeded, seeds inverted; albumen none; embryo straight; radicle pointing to the hilum. Composed of shrubs with usually imparipinnate leaves and serrated leaflets, having the stipulas usually foliaceous, and always adnate to the petioles. This family is distinguished from its allies in the carpels being inserted on the inside of the calyx and inclosed. The various species of the Rose form some of the greatest ornaments to gardens. The fruit of *Rosa canina* and some others is astringent, and is employed against chronic diarrhœa and other maladies. The petals of *Rosa damascena* yield a highly essential oil called Attar, or Otto of Roses; the petals of *Rosa Gallica* are astringent when quickly dried, and are found useful in cases of debility, such as leucorrhœa and diarrhœa, &c. Example, *Rosa*.

86. *Sanguisorbeæ*, Jussieu.—Flowers usually unisexual by abortion; calyx with a thickened tube, and a three, four, or five-parted limb, its tube lined by the disk; petals none; stamens definite, sometimes fewer than there are segments to the calyx, rising from the orifice of the calyx; anthers innate, two-celled, bursting lengthwise, but sometimes one-celled, and bursting transversely; ovarium solitary, having the style proceeding from the apex or base; ovulum solitary, always attached to that part of the ovarium which is next the base of the style; stigma simple, pencilformed or bearded, rarely capitate; nuts usually solitary, inclosed in the indurated tube of the calyx; seed solitary, suspended or ascending; albumen none; radicle superior; cotyledons plano-convex. Composed of herbs or undershrubs; leaves simple, lobed, or pinnate, alternate, stipulate; flowers small, usually capitate. Apetalous flowers, indurated calyx, and solitary carpels distinguish this family. Astringency is the property of this order. Examples, *Alchemilla, Sanguisorba, Poterium, Cliffortia, Acæna*.

87. *Pomaceæ*, Jussieu.—Calyx superior, five-toothed, the odd segment posterior; petals five, unguiculate, inserted in the throat of the calyx; stamens indefinite, rising in a ring from the throat of the calyx; ovaries one to five, adhering more or less to the sides of the calyx, and to each other; ovula generally two, collateral, ascending; styles one to five; stigmas simple; fruit a pome, one to five-celled, seldom spuriously ten-celled; endocarp cartilaginous, spongy, or bony; seeds ascending, twin; albumen none; embryo erect, with flat or convolute cotyledons, and a short, conical, superior radicle. Composed of trees and shrubs with alternate, stipulate, simple, or compound leaves and terminal cymes of flowers. This order is distinguished by the fruit always being a pome, that is it is made up of a fleshy calyx, adhering to fleshy or bony ovaria, containing a definite number of seeds. In *Pomaceæ* the ovula, being in pairs, are placed side by side, while in *Rosaceæ* they are placed one above another. Prussic acid exists in several of the species. The fruit of the greater part are edible, as *Pyrus*, the Pear, *Malus*, the Apple. The Quince, Medlar, Service, Rowan Tree, or Mountain Ash, Hawthorn, are all of this order. Malic acid is the sole acidifying principle in the Rowan Tree, or Mountain Ash, and all others.

88. *Calycanthaceæ*, Link.—Calyx coloured, with a fleshy urceolate tube girding the ovaries, and a many-parted limb; segments unequal, in many series imbricate; petals wanting; stamens numerous, inserted by several series in the fleshy disk, inner ones sterile; anthers adnate, bursting lengthwise outwardly by two cells; ovaria numerous, inserted on the inside of the tube of the calyx as in *Rosa*, one-celled, biovulate, only one of the ovula arriving at maturity; styles terminal, distinct, exserted from the tube of the calyx; stigmas simple; carpels or achenia inclosed within the fleshy tube of the calyx, one-seeded, the pericarp rather horny; albumen none; embryo straight, with convolute cotyledon and an inferior radicle. Composed of shrubs with simple, scabrous, opposite leaves without stipulas, and solitary, pedicellate, yellow, or lurid-purple, sweet-scented flowers. This family agrees with *Rosa* in the carpels being inserted on the inside of a fleshy calyx, and with *Granateæ*

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in the opposite leaves and convolute cotyledons, but it differs from both in the absence of petals and the numerous calycine lobes, and in the anthers bursting outwardly. Examples, *Calycanthus*, *Chimonanthus*.

89. *Granateæ*, D. Don.—Calyx with a turbinate tube and a five or seven-cleft, coriaceous, tubular limb which is valvate in æstivation; petals five to seven; stamens numerous, free; anthers two-celled, bursting in front by two chinks; style filiform; stigma capitate; fruit large, spherical, crowned by the limb of the calyx, divided horizontally in two chambers or parts; the upper chamber five to nine-celled, and the lower one three-celled; the dissepiments which separate the cells are membranous; the placentas of the upper division of the fruit are fleshy, and reach from the parietes to the centre; those of the lower division progress irregularly from the bottom of the fruit; seeds numerous, covered with pellucid baccate pulp; albumen wanting; embryo oblong, with a short straight radicle and spirally convolute cotyledons. Composed of trees or shrubs with tetragonal rather spinose branches, opposite, deciduous, rarely verticillate or alternate leaves, which are usually disposed in fascicles at the axils. Flowers large, scarlet, two to five together, nearly sessile, rising near the tops of the branches. The order differs from *Myrtaceæ* in the leaves being without dots, and from all in the structure of the fruit, &c. *Punica*, or Pomegranate, is the only genus of this order.

90. *Memecyleæ*, De Candolle.—Calyx four to five-lobed, or four to five-toothed; petals four to five in the calyx; stamens eight to ten, free, inserted in the calyx; anthers incurved, two-celled; style filiform; berry crowned by the limb of the calyx, therefore inferior, two to four-celled few-seeded; albumen none; radicle straight; cotyledons foliaceous, convolute. Composed of tropical shrubs, with simple, entire, dotless, opposite leaves, which are sometimes three-nerved; and axillary pedicellate, insignificant flowers which are usually in fascicles. This family is nearly related to *Melastomaceæ* and *Myrtaceæ* in habit, flowers, and opposite leaves, but differs on account of the convolute cotyledons, by which it agrees with *Combretaceæ*, *Granateæ*, and *Calycanthaceæ*. Examples, *Memecylon*, *Mouriria*.

91. *Combretaceæ*, R. Brown.—Flowers usually hermaphrodite, rarely polygamous from abortion; calyx adhering to the ovarium with a four to five-lobed, deciduous limb; petals four to five, inserted nearly at the top of the calycine tube, but wanting altogether in the tribe *Terminalieæ*; stamens eight to ten, inserted in the tube of the calyx, exserted; anthers two-celled; ovarium one-celled, five-ovulate, ovula suspended from the top of the cell; style slender; stigma simple; fruit drupaceous, baccate, or nucamentaceous, one-celled, indehiscent, one-seeded by abortion, and often furnished with four or five longitudinal wings; seed pendulous, filling the cavity of the pericarp; albumen none; embryo straight, having the radicle pointing to the hilum, and the cotyledons usually convolute. Composed of tropical trees or shrubs, with alternate or opposite entire leaves without stipulas, and axillary and terminal spikes or racemes of flowers. This order is nearly related to *Onagrariæ* and *Alangieæ* in the structure of the flower; the apetalous genera agree with *Eleagneæ* and *Santalaceæ* in many important particulars. The bark of *Bucida* is used for tanning in Guiana. The juice of *Terminalia vernix* is used as a varnish by the Chinese; and benzoin is the produce of *Terminalia benzoin*, and the kernels of several species of the same genus are eaten; *Combretum* and *Quisqualis* contain splendid climbing shrubs adorning the trees with garlands of crimson, white, and yellow flowers. This family is divided into two tribes. Tribe 1. *Terminalieæ*. Flowers apetalous. Examples, *Bucida*, *Terminalia*, *Conocarpus*. Tribe 2. *Combreteæ*. Corolla of four or five petals. Examples, *Quisqualis*, *Combretum*.



92. *Vochysieæ*, St. Hilaire.—Sepals four to five, connected at their bases, unequal, the superior one drawn out into a spur, with an imbricate æstivation; petals one or five, inserted at the base of the calyx; stamens one or five, inserted in the bottom of the calyx, when more than one all are sterile, except one which bears a four-celled ovate anther; ovarium free, or adhering to the calyx, three-celled; ovula one, two or more in each cell, attached to the base of the axis; style and stigma simple; capsule trigonal, three-celled, three-valved; valves dehiscing along their middle; albumen none; embryo straight, inverted; cotyledons large, foliaceous, plicate, or convolute; radicle short, superior. Composed of trees, natives of South America, with opposite, tetragonal branches; opposite, quite entire leaves, which are furnished each with two stipulas at the base; racemes usually terminal, panicled, or thyrsoid, pedicels bracteate. In the cotyledons and inverted seeds this order agrees with *Combretaceæ*, and with the genus *Lopezia*, in *Onagrariæ*, the anther being solitary by abortion; in the irregular flowers, trilocular ovarium, and stipulate leaves it appears to be connected with *Violarieæ*. Examples, *Callisthene*, *Vochysia*, and *Erisma*.

93. *Rhizophoreæ*, R. Brown.—Calyx adhering to the ovarium; limb four to thirteen-lobed, with a valvate æstivation; petals inserted in the calyx, four to thirteen in number; stamens inserted with the petals, usually equal to them in number, rarely double or triple that number, free; anthers erect, inserted by their bases; ovarium adnate to the calyx, two-celled, each cell containing two or more pendulous ovula; fruit indehiscent, one-celled, one-seeded, crowned by the limb of the calyx; seed pendulous; albumen none; embryo with a long radicle and flat cotyledons. Composed of tropical trees and shrubs, with opposite, simple, entire, or toothed leaves, interpetiolar stipulas and axillary peduncles. This order is allied to a number of others through the various genera which compose it; but the lengthened embryo will be sufficient to distinguish it. The species of Mangrove are remarkable in tropical countries for growing on the shores of the sea and rivers. The seeds germinate while adhering to the parent, and push forth a long fusiform radicle which lengthens till it reaches and fixes itself in the mud, and forms a new individual. The bark is astringent. Examples, *Rhizophora*, *Carallia*.

94. *Onagrariæ*, Jussieu.—Calyx adnate to the ovarium; limb usually four-lobed, rarely two-lobed, with a valvate æstivation; petals four, inserted in the top of the calycine tube, usually regular, with a twisted æstivation, rarely wanting; stamens usually twice as many as there are petals, rarely equal that number, free; anthers two-celled; ovarium many-celled, generally crowned by a cup-shaped gland; style filiform; stigma capitate or lobed; fruit capsular, baccate, or drupaceous, two or four-celled; seeds many in each cell, rarely solitary, fixed to the central placenta; albumen wanting; embryo straight, with a long terete radicle and short cotyledons. Composed of herbs or shrubs, with simple, alternate or opposite, entire, toothed or pinnatifid leaves;

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and axillary flowers which are disposed in spikes or racemes. Distinguished from *Lythrarieæ* in the adnate calyx, and from *Halorgeæ* in the filiform style, the want of albumen, and erect seeds. Most of the genera are beautiful, as *Fuchsia*, *Epilobium*, *Œnothera*, *Codetia*, &c. The properties of the order are little known. It is divided into five tribes, which are considered by some botanists as many separate orders. Tribe 1. *Montinieæ*. Fruit capsular; seeds imbricate, winged. Woody plants. Example, *Montinia*. Tribe 2. *Fuchsieæ*. Fruit baccate; calycine tube drawn out beyond the ovarium. Woody plants. Example, *Fuchsia*. Tribe 3. *Onagreæ*. Fruit capsular; seeds not winged; calycine tube as in the last tribe. Herbs. Examples, *Epilobium*, *Gaura*, *Œnothero*, *Clorkia*. Tribe 4. *Jussieueæ*. Fruit capsular; calyx not drawn out beyond the ovarium, but dividing at its top. Herbs. Examples, *Jussieuo*, *Isnardia*. Tribe 5. *Circeæ*. Calyx like that of the last tribe, but the limb is deciduous; fruit capsular; stamens two, one of which is usually converted into a petal. Examples, *Circæa*, *Lepezia*.

95. *Halorageæ*, R. Brown. Calycine tube adhering its whole length to the ovarium; limb small, four-parted, entire, or almost none; petals four, minute, inserted in the upper part of the calyx, rarely wanting; stamens inserted with the petals, four or fewer by abortion; ovarium inferior, of one or more cells; style none; stigmas as many as there are cells in the ovarium, sessile, papillose, or pencilformed; fruit dry, indehiscent, membranous or bony, consisting of one or more cells; seeds solitary in the cells, pendulous; albumen fleshy; embryo straight; radicle terete, elongated, superior; cotyledons short, minute. Composed of herbs or undershrubs, usually inhabiting water or bogs, with alternate, opposite, or verticillate leaves; flowers minute, axillary, sessile, or disposed in terminal spikes, occasionally unisexual. This order is divided into three tribes. Tribe 1. *Cercodianæ*. Limb of calyx four-parted; stamens four or eight; petals four; fruit four-celled. Examples, *Serpicula*, *Haloragis*, *Goniocarpus*, *Cercodia*, *Proserpinaca*, and *Myriophyllum*. Tribe 2. *Callitrichineæ*. Limb of calyx not conspicuous; petals wanting; stamens one or two; fruit four-celled, four-seeded. Example, *Callitriche*. Tribe 3. *Hippurideæ*. Limb of calyx entire; petals wanting; stamen one; fruit nucamentaceous. Example, *Hippuris*.

96. *Hydrocarydeæ*, Link. Tube of calyx adhering to the ovarium; limb four-parted; petals four, rising from the throat of the calyx; stamens four; ovarium inferior, two-celled; ovulum solitary, pendulous; style filiform, thickened at the base; stigma capitate; fruit hard, indehiscent, one-celled, one-seeded, crowned by the indurated segments of the calyx; seed large, solitary; albumen none; cotyledons very unequal. Composed of floating herbs, having the lower leaves opposite, and the upper ones alternate; those under water cut into capillary segments; petioles tumid in the middle; flowers axillary. Distinguished from *Onagrariæ* in habit, and solitary, pendulous ovulum, but by some botanists it is said to be more nearly allied to *Halorageæ*, from which it is only separated by the large seeds, unequal cotyledons, evident calyx, and want of albumen. The seeds of all are eatable. Example, *Trapa*, or Water-Caltrops.

97. *Lythrarieæ*, Jussieu.—Calyx gamosepalous, with a tubular or campanulate tube; lobes having the sinuses between them usually lengthened into other lobes or teeth, which are produced on the outside; æstivation valvate or open; petals variable in number, inserted between the lobes of the calyx, deciduous, rarely wanting; stamens variable in number, inserted below the petals; anthers oval, two-celled, inserted by their backs; ovarium free, two to four-celled; style filiform; stigma usually capitate; capsule membranous, covered by the calyx, one-celled; seeds numerous, small, fixed to the central placenta; albumen none; embryo straight; radicle pointing to the hilum; cotyledons flat and foliaceous. Composed of herbs, rarely shrubs, with generally tetragonal branches, and usually opposite, entire, feather-nerved leaves, without stipulas or glands; flowers axillary or disposed in spikes or racemes at the tops of the branches. The free ribbed calyx is sufficient to separate this order from *Onagrariæ* and *Melastomaceæ*, to which it is nearly allied, and also from the latter by the position of the veins of the leaves. Astringency is the principal property of the order. The *Lawsonia inermis* is the plant from which the Henna of Egypt is obtained. The bruised leaves of *Ammania vesicatoria* are used in India to raise blisters in rheumatisms. *Physocalymma* is the rose-wood of commerce. The order is divided into two tribes. Tribe 1. *Salicarieæ*. Calycine lobes separate, or somewhat valvate in æstivation; petals numerous; sinuses of calyx drawn out into either teeth or lobes; seeds wingless. Examples, *Peplis*, *Ammania*, *Lythrum*, *Cuphea*, *Heimia*, *Lawsonia*, and *Grislea*. Tribe 2. *Lagerstrœmieæ*. Calycine lobes, valvate in æstivation; petals equal in number to the lobes of the calyx; stamens twice or thrice the number of the petals; seeds winged. Example, *Lagerstrœmia*.

98. *Melastomaceæ*, D. Don.—Calyx four, five, or six-lobed, adhering more or less to the angles of the ovarium, but separate from its surface between the angles, and thus forming a number of cavities into which the anthers are curved before the expansion of the flower; petals four, five, or six, rising at the base of the calycine segments, or from the disk that lines the tube, with a twisted æstivation; stamens usually twice as many as there are petals, but sometimes of an equal number; in the first those that are opposite to the calycine lobes are alone fertile; anthers long, two-celled, usually bursting by two pores at their apices, seldom longitudinally; ovarium with several cells and indefinite ovula; style one; stigma simple, capitate or minute; a cup or urceolus often present on the top of the ovarium, and surrounding the base of the style; pericarp dry and distinct from the calyx, or succulent and combined with it; placentas attached to the central column, tending to the middle of the valves; seeds numerous; albumen none; embryo straight or curved. Composed of trees and shrubs or herbs, with opposite, undivided, usually entire leaves, without dots, but having several ribs; flowers terminal, usually thyrsoid. Long-beaked anthers, opposite leaves, having several great veins or ribs running from the base to the apex, is sufficient to distinguish this order from all others. Astringency is the only property of the family. This order is divided into suborders and tribes, viz. Suborder 1. *Melastomeæ*. Anthers opening by one or two pores at their apices. Tribe 1. *Lavoisiereæ*. Ovarium free, bald; capsule dry; seeds with a lateral, linear hilum. Examples, *Meriana*, *Axinæa*. Tribe 2. *Rhexieæ*. Anthers opening by one pore; ovarium free, bald; capsule dry; seeds cochleate, with an orbicular, basilar hilum. Examples, *Rhexio*, *Microlicia*. Tribe 3. *Osbeckieæ*. Anthers opening by one pore; ovarium free or adnate,



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crowned by bristles or scales; seeds like those of the preceding tribe. Examples, *Osbeckia*, *Melastoma*, *Pleroma*, *Aciotis*. Tribe 4. *Miconieæ*. Anthers opening by one or two pores; ovarium adnate to the calyx; fruit baccate; seeds not cochleate. Examples, *Miconia*, *Sonerila*, *Tococa*, *Conostegia*, *Blakea*. Suborder 2. *Charianthea*. Anthers two-celled, bursting by two longitudinal chinks; fruit fleshy; seeds cuneate, angular. Examples, *Charianthus* and *Astronia*.

99. *Alangieæ*, De Candolle.—Calyx with an egg-shaped tube, which is rather constricted at the apex, and a campanulate five to ten-toothed limb; petals five to ten, linear, reflexed; stamens exserted, numerous, free, villous at their bases; anthers adnate, linear, two-celled, bursting inwardly by longitudinal double chinks, often barren; disk fleshy at the base of the calycine limb; drupe oval, fleshy, and ribbed a little, rather tomentose, containing a valveless, one-celled, one-seeded nut, having a hole at the top; albumen fleshy; embryo straight; radicle ascending; cotyledons foliaceous. Composed of Indian trees, with usually spinescent branches, and alternate, entire leaves, without stipulas or dots; flowers few, sessile, in axillary fascicles; fruit eatable. Number of petals, adnate anthers, albuminous seeds, separate this order from its allies. Example, *Alangium*.

100. *Philadelpheæ*, D. Don. Calyx with a turbinate tube, which is adnate to the ovarium, and a four to ten-parted limb; petals equal in number to the lobes of the calyx, with a convolutely imbricate æstivation; stamens twenty to forty, inserted in the throat of the calyx in one or two series; styles almost distinct, or more or less combined; stigmas many; capsule half adhering to the calyx, ten-celled, many-seeded; seeds small, subulate, smooth, heaped together at the angles of the cells on the angular placenta, each covered by a loose membranous aril; albumen fleshy; embryo inverted. Composed of ornamental hardy shrubs, with opposite, dotless, toothed, or almost entire exstipulate leaves, opposite, axillary, and terminal, cymose, or panicled peduncles, bearing white, sweet, but heavy scented flowers. The arillate, toothed, albuminous seeds, and toothed, dotless leaves are sufficient to separate this order from *Myrtaceæ*. Examples, *Philadelphus*, the Syringa or Mock Orange, *Decumaria*, and *Deutzia*.

101. *Myrtaceæ*, R. Brown. Calyx four, five, six, or eight-cleft, the limb sometimes cohering in two portions, sometimes in one, and then falling off like a cap or lid; petals perigynous, as many as there are segments to the calyx, sometimes slightly united at their very bases, rarely wanting, with an imbricate æstivation; stamens inserted with the petals, usually indefinite, distinct, monadelphous, or variously polyadelphous, curved inwards in æstivation; anthers ovate, two-celled, bursting lengthwise; ovarium cohering with the tube of the calyx, formed of two, four, five, or six carpels, the dissepiments rarely imperfect, and hence one to six-celled; style and stigma simple; placentas in the axis; fruit dry or fleshy, dehiscent or indehiscent, two to six, or more celled, or by the obliteration of the dissepiments only one-celled; seeds usually indefinite, rarely solitary or few; albumen none; embryo straight or curved; radicle next the hilum; cotyledons distinct or consolidated into one mass with the radicle. Composed of trees and shrubs, with usually opposite, rarely alternate, entire, rarely serrated leaves, which are usually full of transparent dots. Dotted leaves with marginal ribs, an inferior ovarium, and single style, are the great features of this order. The dots in the leaves and other parts indicate the presence of a volatile oil, which is aromatic and pungent, and gives to the plants the fragrance which has caused them to be celebrated by poets of all ages. The Allspice, the Clove, the Guava, and the Myrtle are of this order. The leaves of some are used as substitutes for tea. *Melaleuca Cajeputi*, from which the celebrated oil of that name is obtained, is also of this order. The order is divided into four tribes. Tribe 1. *Chamælaucieæ*. Ovarium one-celled; leaves opposite, dotted. Examples, *Chamælaucium* and *Calytrix*. Tribe 2. *Leptospermeæ*. Capsule many-celled; leaves opposite or alternate, usually dotted. Examples, *Leptospermum*, *Eucalyptus*. Tribe 3. *Myrteæ*. Fruit baccate; stamens free; leaves opposite, always dotted. Examples, *Myrtus*, *Piamenta*, and *Eugenia*. Tribe 4. *Barringtonieæ*. Fruit fleshy, one-celled; stamens monadelphous; leaves opposite or verticillate, without dots. Examples, *Barringtonia* and *Gustavia*.

102. *Lecythideæ*, Richard. Calyx two to six-leaved, or urceolate, with a divided limb; æstivation valvate or imbricate; corolla of six unequal petals, which cohere at their bases; æstivation imbricate; stamens indefinite, epigynous, combined into a petaloid, cucullate, unilateral body; ovarium two to six-celled, either opening by a lid or remaining closed; seeds numerous, covered by a thick integument; albumen none; embryo large, undivided, or with two large, flat, fleshy, or leafy cotyledons, which are sometimes folded upon the radicle which is next the hilum. This order consists of large trees, with entire or toothed leaves, destitute of pellucid dots, but with minute, deciduous stipulas. Flowers large, terminal, or lateral, solitary or racemose. This differs from *Myrtaceæ* in the alternate, dotless leaves and irregular flowers. The order contains the *Couroupita Guianensis*, called in Guiana *Abricot sauvage*, whose fruit is vinous and pleasant. The fleshy seeds of most of the species of *Lecythis* are edible, and the bark of *L. ollaria* is readily separated by beating into a number of distinct layers, so as to have the appearance of thin satiny paper, which the Indians cut into pieces as wrappers for their cigars. Poiteau says he has counted one hundred and ten of these layers. The well-known Brazil nuts of the shops are the produce of *Bertholetia excelsa*, a tree of this order.

103. *Cucurbitaceæ*, Jussieu.—Flowers hermaphrodite or unisexual, axillary; calyx gamosepalous, five-toothed; corolla usually five-parted, seldom of five petals, rising from the margin of the torus, reticulately veined, sometimes fringed; stamens five, distinct or combined into one or three parcels; anthers two-celled, very long, sinuous, rarely short and ovate; style crowned by three or five two-lobed stigmas, which are thick and velvety, but rarely fringed; ovarium inferior, one-celled; fruit fleshy, crowned by a scar, formed from the falling of the calycine limb, one-celled, with three parietal placentas, which are indicated on the outside by nerves; umbilical funicles tumid; seeds usually obovate, flat, enveloped in dry or succulent arils, fixed to the parietes of the fruit; hilum oblique at the top of the seed; embryo straight, flat; albumen none; radicle basilar, directed towards the hilum. Composed of tendrilled, climbing or trailing, annual or perennial herbs, with fibrous or tuberous roots, palmate or lobed, scabrous leaves, and solitary, lateral, simple, or divided tendrils; flowers solitary, panicled or in fascicles; branches rising between the leaves and tendrils. Distinguished from *Passifloreæ*, to which it is nearly allied, by the

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monopetalous corolla, sinuous anthers, unisexual flowers, and want of albumen. The Gourd, Pumpkin, Melon, and Cucumber belong to this order, also the bitter purgatives Colocynth, the *Momordica, Elaterium*, or Squirting Cucumber, and *Bryonia*. The seeds of *Ampelosicyos* are eatable. The order is divided into two tribes. Tribe 1. *Nhandirobeæ*. Tendrils axillary, in the place of peduncles; flowers dioecious. Examples, *Feuillea, Zanonia*. Tribe 2. *Cucurbiteæ*. Tendrils lateral, stipular; flowers hermaphrodite, monoecious, or dioecious. Examples, *Lagenaria, Cucumis, Benincasa, Bryonia, Sicyos, Elaterium, Momordica, Sechium, Trichosanthes, Cucurbita, Anguria, Gronovia*, &c.

104. *Papayaceæ*, Martius.—Flowers unisexual; calyx minute, five-toothed; corolla monopetalous, in the male tubular, with five lobes and ten stamens, all rising from the same line, those opposite the lobes are sessile, and the others on short filaments; anthers adnate, two-celled; corolla in the female divided almost to the base into five segments; ovarium superior, one-celled, with five parietal, polyspermous placentas; stigma sessile, five-lobed, torn; fruit fleshy and succulent, indehiscent, one-celled, many-seeded; seeds enveloped in a loose, mucous coat, with a brittle, pitted testa; embryo with flat cotyledons and a terete radicle, which is turned to the hilum; albumen fleshy. Composed of trees without branches, abounding in an acrid milky juice, bearing alternate, palmately lobed, petiolate leaves. Nearly allied to *Passifloreæ* and *Cucurbitaceæ* from the structure of the fruit. The fruit of the *Papaw* is eaten raw, and cooked in the manner of turnips. The trees have the singular property of rendering the toughest animal substances tender, by causing a separation of the muscular fibre; and its very vapour even does this. Example, *Carica Papaya*.

105. *Belvisiaceæ*, R. Brown.—Calyx monosepalous, persistent, with a divided limb; corolla monopetalous, plaited, deciduous, inserted in the summit of the calycine tube; stamens ten or indefinite, with an outer row of abortive ones, which are converted into a jagged, monopetalous, inner corolla, distinct or polyadelphous; anthers two-celled; ovarium adhering to the tube of the calyx, one-celled, containing an indefinite number of ovula; style short, crowned by a lobed or angular stigma; fruit a one-celled berry, crowned by the lobes of the calyx; seeds numerous, attached to parietal placentas. Composed of shrubs with alternate, simple leaves without stipulas, and axillary, solitary, hermaphrodite flowers. Allied to *Cucurbitaceæ* and *Passifloreæ*. Examples, *Belvisia* or *Napoleonea*, and *Asteranthus*.

106. *Passifloreæ*, Jussieu.—Sepals five or ten, combined at their bases into a short or elongated tube, but free at their apices, and disposed in a single or double series; outer ones large and foliaceous, inner ones, when present, more petaloid, and which are probably petals; the sides of the throat are lined with filamentous, annular, or membranous, coloured processes, which are disposed in one or more series, having the bottom generally closed by a lid-formed appendage; petals five or wanting; stamens five, except in *Smeathmannia*, in which they are indefinite; filaments usually combined into a long tube, which sheaths the stipe of the ovarium; anthers fixed by their backs, peltate, two-celled; ovarium ovate, free, seated on an elongated stipe; styles three, rising from the same point, each crowned by a somewhat two-lobed stigma; fruit superior, stalked, one-celled, three-valved, with three intervalvular, parietal, polyspermous placentas, dry and dehiscent, or fleshy and indehiscent; seeds numerous, compressed, scrobiculate, usually enveloped in pulpy arils; embryo straight; radicle turned to the hilum; cotyledons flat, foliaceous; albumen fleshy and thin. Composed of usually climbing shrubs or herbs; leaves various in form, alternate, stipulate, generally bearing glands on the limbs or petioles; peduncles axillary, one-flowered, rarely branched and many-flowered, sometimes changed into tendrils; in the upright species all the peduncles are floriferous; involucrum, when present, of three leaves, always at the articulation of the peduncle. The beauty of the various species of Passion Flower is well known. The fruit of some species is eatable. The order is divided into two tribes. Tribe 1. *Paropsieæ*. Petals five; ovarium sessile; upright shrubs without tendrils. Examples, *Smeathmannia, Paropsia*. Tribe 2. *Passifloreæ-veræ*. Calyx deeply five-parted; petals five or wanting; stamens five; ovarium stalked; generally climbing plants, having the peduncles often changed into tendrils. Examples, *Passiflora, Disemma, Tacsonia, Murucuia, Modecca*.

107. *Malesherbiaceæ*, D. Don.—Calyx tubular, membranous, inflated, five-lobed, with an imbricate æstivation; petals five, persistent, rising from the outside of a membranous crown, with a convolute æstivation; stamens five to ten, perigynous, filiform, distinct, or connected with the stipe of the ovarium; anthers two-celled, versatile; ovarium superior, stipitate, one-celled, having the ovula rising by funicles from three parietal placentas at the bottom of the cell; styles three, filiform, rising at distinct points from the apex of the ovarium; stigmas clavate; fruit a one-celled, three-valved, membranous, many-seeded capsule; testa crustaceous, brittle, furnished with a fleshy crust and no arillus; albumen fleshy; embryo terete; radicle next the hilum. Composed of erect herbs or half-shrubby plants, clothed with glandular pubescence; leaves alternate, simple, or lobed, without stipulas; flowers axillary or terminal, solitary, yellow, or blue. This differs from *Passifloreæ* in the insertion of the styles, versatile anthers, short placentas, terete embryo, want of arillus and stipulas, and in habit. It agrees with *Turneriaceæ* in habit, but differs in many points of structure. Example, *Malesherbia*.

108. *Loaseæ*, Jussieu.—Tube of calyx adhering to the ovarium, or girding it closely; limb five-parted, rarely four-parted, persistent; petals five, rarely four, often ten, rarely eight, when the latter number, they are disposed in two series, those of the inner series usually much smaller, scale-formed, and truncate at their apices, and inserted in the throat of the calyx; stamens indefinite, rising within the petals, distinct, or joined into several parcels at their bases, in front of the petals, within the cavities of which they lie in æstivation; filaments subulate, frequently destitute of anthers; ovarium adnate with the calyx, or enclosed in it, one-celled, with several parietal placentas, or a central lobed one; style one, composed of three, five, or seven joined ones, crowned by as many stigmas or lobes; fruit a dry or succulent capsule, crowned by the limb of the calyx, three, four, or seven-valved, with an equal number of placentas originating at the margins of the valves, which are often drawn out so far as to form dissepiments; seeds numerous, with arils; albumen fleshy; radicle pointing to the hilum; cotyledons small, flat. Composed of pilose or bristly, usually stinging herbs;



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leaves opposite or alternate, without stipulas, usually variously divided, but sometimes simple; peduncles axillary, one-flowered; flowers elegant. This order agrees with *Cucurbitaceæ* in the inferior, unilocular fruit and parietal placentas. It has the rigid stinging hairs of *Urticeæ*. Examples, *Bartonia*, *Loasa*, *Mentzelia*, *Blumenbachia*.

109. *Turneriaceæ*, Kunth.—Calyx free, five-cleft, deciduous, usually coloured, with an imbricate æstivation; petals five, inserted in the upper part of the calycine tube, narrow at their bases, with a twisted æstivation; stamens five, inserted in the calyx below the petals, free; anthers oblong, erect, two-celled; ovarium free, one-celled, containing numerous ascending ovula, which are fixed to three linear parietal placentas; styles three or six, usually more or less bifid, and cleft into many stigmas at apex; capsule three-valved, dehiscing from the apex as far as the middle; seeds subcylindrical, curved, crustaceous, reticulated, furnished each with a thin membranous arillus on one side, having the hilum at the base; albumen fleshy; embryo a little incurved, spatulate; radicle turned towards the hilum; cotyledons plano-convex. Composed of herbs and undershrubs, beset with simple hairs or down; leaves alternate or scattered, simple, toothed, rarely pinnatifid, without stipulas, having occasionally two glands at the apices of the petioles; flowers axillary, sessile or stalked; peduncles one or many-flowered, articulated in the middle, or furnished with two small bracteoles, distinct, or connected with the petioles; corollas usually yellow, rarely blue. The superior one-celled fruit, parietal placentas, and definite stamens distinguish it from *Loaseæ*. The presence of glands on the petioles, and many other characters, confirm its affinity with *Passifloreæ*. Examples, *Turnera*, *Piriqueta*.

110. *Fouquieraceæ*, De Candolle.—Sepals five, persistent, with an imbricate æstivation; corolla five-lobed, inserted in the bottom of the calyx or in the torus; stamens ten to twelve, exserted, inserted with the corolla; anthers two-celled; ovarium free, sessile; style filiform, trifid at apex; capsule trigonal, three-valved, three-celled from the intervalvular dissepiments going to the centre of the fruit; seeds compressed, winged, fixed to the axis of the fruit, few coming to maturity; albumen fleshy; embryo straight, with flat cotyledons. Composed of trees and shrubs, natives of Mexico; leaves, when young, in fascicles, in the axils of spines or cushions, quite entire and rather fleshy; flowers scarlet, disposed in terminal spikes or racemes. Separated from *Portulaceæ* on account of the monopetalous corolla and the three loculicidal cells of the capsule, and by the straight embryo, which is placed in the centre of the albumen. It approaches *Turneriaceæ* and *Loaseæ* in the form of the fruit, and the monopetalous *Crassulaceæ* in the structure of the flowers. Examples, *Fouquiera* and *Bronnia*.

111. *Portulaceæ*, Jussieu.—Calyx free or adnate to the ovarium at the very base, generally of two sepals, rarely of three or five, always cohering at their bases; petals usually five, seldom three, four, or six, rarely wanting, distinct, or combined into a short tube at their bases; stamens variable in number, distinct or adnate to the bases of the petals, inserted irregularly along with the petals into the base of the calyx; anthers two-celled, versatile; style filiform, cleft into numerous stigmas at the apex, or it is wanting or nearly so, in this case the stigmas rise from the top of the ovarium; capsule one-celled, opening either transversely or by three valves, but it is occasionally one-seeded and indehiscent; seeds numerous when the fruit is dehiscent, attached to the central placenta; albumen farinaceous; embryo curved round the circumference of the albumen, with a long radicle and oblong cotyledons. Composed of fleshy shrubs and herbs, with alternate, rarely opposite, entire, succulent leaves, either without stipulas or furnished with membranous ones at the bases of the petioles on both sides; flowers axillary and terminal, generally expanding in the full sun, and of short duration. So nearly allied to *Caryophylleæ*, from which it is alone distinguished by the perigynous insertion of the stamens and their being opposite the petals. The genera with one-seeded capsules, and those with membranous stipulas, agree with *Paronychieæ*, and the apetalous genera with the *Ficoideæ*. Insipidity and want of smell is the principal quality of this order. The common Purslane and *Claytonia perfoliata* are good substitutes for spinach. Examples, *Portulaca*, *Talinum*, *Calandrinia*, *Portulacastrum*, *Claytonia*, *Montia*, *Anacampseros*.



112. *Paronychieæ*, St. Hilaire. Sepals usually five, seldom three or four, distinct or joined to their middle, sometimes almost to their apices; petals small, scale-formed, inserted between the lobes of the calyx, but occasionally wanting, or converted into stamina; stamens perigynous, distinct, opposite the sepals, if equal to them in number, but they are often fewer by abortion; ovarium free; styles two or three, distinct or partially joined; fruit small, dry, usually membranous, opening by three valves, or valveless and indehiscent; seeds when numerous fixed to the central placenta, but when solitary and pendulous rising upon a funicle from the bottom of the cell; albumen farinaceous; embryo cylindrical, more or less curved, placed on the side of the albumen; radicle pointing to the hilum; cotyledons small. Composed of herbs or half shrubby plants, with opposite or alternate and often fascicled, sessile, entire leaves, and scarious stipulas. Flowers insignificant, sessile, axillary, or variously disposed into terminal cymes; bracteas scarious like the stipulas. The scarious stipulas and bracteas of this order will distinguish it from all others. The position of the stamens in front of the sepals instead of the petals distinguishes it from *Portulaceæ*. The concrete carpells in *Crassulaceæ* will be sufficient to distinguish it from that order. The order is divided into four tribes. Tribe 1. *Telephieæ*. Calyx five-parted; petals and stamens five, inserted in the bottom of the calyx; styles three; leaves alternate. Examples, *Telephium*, *Corrigiola*. Tribe 2. *Illecebreæ*. Calyx five-parted; petals five or wanting; stamens two or three, inserted in the bottom of the calyx; capsule indehiscent, one-seeded; leaves opposite. Examples, *Herniaria*, *Illecebrum*, *Paronichia*. Tribe 3. *Polycarpeæ*. Calyx five-parted; petals five or wanting; stamens one to five, inserted in the bottom of the calyx; capsule many-seeded; leaves opposite. Examples, *Polycorpæa*, *Ortegia*, *Polycarpon*. Tribe 4. *Pollichieæ*. Calyx five-toothed; stamens one or two, inserted in the throat of the calyx; petals none; fruit indehiscent, one-seeded; leaves opposite or subverticillate. Example, *Pollichia*.

113. *Scleranthaceæ*, Link. Calyx four or five-parted; stamens one to ten, inserted in the orifice of the tube; ovarium one-seeded; styles two or only one, emarginate; fruit a membranous utricle, inclosed within

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the hardened calyx; seed hanging from the top of a funicle which rises from the bottom of the cell; embryo cylindrical, curved round the farinaceous albumen. Composed of small herbs with opposite leaves and destitute stipulas, which distinguish this family from *Paronychieæ*. The order is divided into three tribes. Tribe 1. *Scleranthea*. Calyx four to five-toothed; petals none; stamens one to ten; styles two or one; fruit one-seeded. Examples, *Scleranthus*, *Mniarum*. Tribe 2. *Queriaceæ*. Calyx five-parted; petals none; stamens ten, inserted in the bottom of the calyx; carpels three-valved, one-seeded. Example, *Queria*. Tribe 3. *Minuartieæ*. Calyx five-parted; petals wanting or very minute; stamens three to ten, inserted in the bottom of the calyx; styles three; capsule three-valved, many-seeded; seeds fixed to the central placenta. Examples, *Minuartia*, *Læflingia*.

114. *Crassulaceæ*, De Candolle. Sepals three to twenty, joined together more or less at their bases; petals equal to the sepals in number, either distinct or united into a gamopetalous corolla; stamens distinct, inserted with the petals in the bottom of the calyx, and when equal in number to them they are alternate with them; or when twice that number, those opposite the petals are shortest; anthers two-celled; nectariferous scales several, one at the base of each ovarium, but they are sometimes obsolete; ovaria equal in number to the petals, opposite them, and usually distinct, all one-celled, and tapering each into a stigma, dehiscing when ripe by a longitudinal fissure, except in the *Diamorpha*, which opens on the back; seeds in two rows, attached to the edges of the sutures, variable in number; albumen fleshy and sparing; embryo straight in the axis of the albumen; radicle directed to the hilum. Composed of fleshy, succulent herbs or undershrubs, with entire or pinnatifid leaves, destitute of stipulas; flowers usually disposed in cymes, seldom rising from the forks, often arranged on one side of the branches of the cymes. The nectariferous scales in this order is sufficient to distinguish it from all its allies, *Saxifragaceæ* and *Paronychieæ*. The properties are refrigerant and abstergent, mixed with acidity. Malic acid is said to exist in the Houseleek. In Madeira the fishermen rub their nets with the fresh leaves of *Sempervivum glutinosum*, supposing that it renders them more durable. This order is divided into two tribes. Tribe 1. *Crassulaceæ legitimæ*. Carpels distinct, opening in front by a longitudinal fissure. Examples, *Tillæa*, *Bulliardia*, *Septas*, *Crassula*, *Rochea*, *Kalosanthes*, *Kalanchoe*, *Cotyledon*, *Echeveria*, *Sedum*, *Sempervivum*, *Umbilicus*, *Bryophyllum*. Tribe 2. *Crassulaceæ anomalæ*. Carpels united at their bases into a many-celled capsule. Examples, *Penthorum*, *Diamorpha*.

115. *Ficoideæ*, Jussieu. Sepals generally five, but varying from four to eight, more or less connected at their bases, either cohering with the ovarium, or almost free from it, equal or unequal, with a valvate æstivation; petals indefinite, narrow, combined a little way at their bases, seldom wanting; stamens indefinite, distinct, rising from the calyx; anthers two-celled, oblong, incumbent; ovarium superior or inferior, many-celled, crowned by many distinct stigmas; capsule naked or girded by the fleshy calyx, generally many-celled, but often as few as five-celled, dehiscing in a stellate manner at the apex; seed definite or indefinite, fixed to the inner angles of the cells; albumen farinaceous; embryo curved, placed outside the albumen. Composed of shrubs or herbs variable in habit, with fleshy, succulent, opposite, simple leaves, and usually terminal, gaudy flowers of various hues. The curved embryo, mealy albumen, perigynous stamens, and succulent, fleshy leaves, distinguish this order from its allies. The greater number of the plants are inhabitants of the hottest sandy plains of South Africa. The succulent leaves of some kinds are eaten, such as New Zealand Spinach, the *Tetragonia expansa*, *Sesuvium portulacastrum*, and others. Others yield an abundance of soda. Examples, *Mesembryanthemum*, *Tetragonia*, *Aizoon*, *Glinus*.



116. *Nitrariaceæ*, Lindley. Calyx inferior, five-toothed, fleshy, persistent; petals five, rising from the calyx, inflexed, with a valvular æstivation; stamens fifteen, perigynous; anthers innate, bursting by two oblique furrows; ovarium superior, of three or more cells, tapering into a continuous style, which is terminated by as many lines as there are cells; ovula hanging by long funicles; fruit drupaceous, opening by three or six valves; seeds solitary; albumen none; embryo straight; radicle next the hilum. Composed of shrubs with deciduous, succulent, alternate leaves; they are also in fascicles. Flowers solitary or disposed in cymes. The different embryo and peculiar æstivation of the petals readily distinguish this family from *Ficoideæ*. Example, *Nitraria*.

117. *Neuradiaceæ*, Arnott. Calyx five-cleft, persistent, with a slightly imbricate æstivation; petals five, perigynous, with an imbricate æstivation; stamens ten, perigynous; ovarium cohering with the calycine tube at the base, of five or ten cells, that is composed of so many carpels; ovula solitary, pendulous; styles five or ten; capsule five or ten-celled, depressed, indehiscent; seeds solitary, pendulous, germinating within the capsule; albumen none; embryo curved; radicle next the hilum; cotyledons large. Composed of herbs with pinnate or bipinnatifid, membranous, tomentose leaves furnished with stipulas. The curved embryo, many-celled fruit, and different habit, readily distinguish it from the *Ficoideæ*. Examples, *Neuradia*, *Grielum*.

118. *Cacteæ*, De Candolle. Sepals usually indefinite and readily confounded with the petals, united together at their bases, and adnate to the ovarium a considerable way, with a smooth tube, or having the lobes of the calyx crowning the fruit, in which case the tube is scaly; petals disposed in two or more series, readily confounded with the inner sepals and somewhat united with them, sometimes they are irregular, in which case they are combined into a long tube at their bases, but sometimes they are equal and distinct to the very base, and therefore form a rotate corolla; stamens indefinite, cohering more or less with the petals or inner sepals, disposed in many series, filiform, irritable to the touch in *Opuntia*; anthers ovate, versatile, two-celled; ovarium obovate, fleshy, one-celled, containing numerous ovula arranged upon parietal placentas which are in number equal to the lobes of the stigma; style filiform, solid or fistular; stigmas numerous, spreading or collected into a cluster; fruit fleshy, one-celled, many-seeded, smooth and crowned by the calyx, or covered with scales, scars, or tubercles, with an umbilicate apex, seeds imbedded in the pulp at maturity, oval or obovate; albumen none; embryo straight, curved, or spiral; radicle short, blunt; cotyledons flat, thick, foliaceous in *Opuntia* and other leaf-bearing genera; very small in *Melocactus*, and probably almost obsolete in *Mammil-*

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*laria*, and other leafless genera. Composed of fleshy, succulent, grotesque shrubs, very variable in habit; the stems usually angular, winged, or beset with tubercles or mammæ, rarely cylindrical, usually jointed; leaves usually wanting, but when present small, caducous, and terete, rarely flat and expanded, sometimes alternate, but usually disposed in a spiral order, always glabrous and fleshy; prickles or bristles in fascicles rising from the axils of the leaves; in the leafless genera the fascicles of spines are disposed along the angles of the stem, and rise from tubercles; flowers very variable, showy or minute, usually solitary, sessile, rarely in fascicles, ephemeral, expanding by night or by day. The peculiar habit of the plants contained in this order readily distinguish them from all others. The fruit of many species are refreshing and agreeable to the taste, as the Indian Fig. The order is divided into two tribes. Tribe 1. *Opuntiaceæ*. Ovula fixed to the parietes of the fruit. Examples, *Mammillaria*, *Melocactus*, *Cereus*, *Epiphyllum*, *Opuntia*, *Pereskia*. Tribe 2. *Rhipsalideæ*. Ovula fixed to the central axis of the fruit. Example, *Rhipsalis*.

119. *Grossularieæ*, De Candolle. Calyx superior, with a four or five-parted limb; petals five, inserted in the calycine throat, stamens four to five, rarely six, conical or cylindrical; anthers two-celled, opening inwardly; ovarium one-celled, with two opposite parietal placentas and numerous ovula; style two, three, or four-cleft; fruit succulent, nearly globose, umbilicate at the apex from the persistent calyx, one-celled, many-seeded; seeds arillate, hanging by long, filiform funicles; albumen horny; embryo minute, located at the sharpest end of the seed, excentral; radicle blunt next the hilum. Composed of unarmed or spinose shrubs with alternate, lobed, or cut leaves which are plicate while in the bud; pedicels each furnished with a bractea at the base, and two bracteoles under the ovarium; flowers greenish-white, yellow, or red, rarely unisexual. Very nearly allied to *Cacteæ*, but it is readily distinguished from it by the definite stamens, albuminous seeds, distinct calyx, corolla, and habit. The Gooseberry, White, Red, and Black Currant belong to this order. Malic acid exists in the fruit of all. The Black Currant is tonic and stimulant, and has fragrant glands on its leaves and flowers. Example, *Ribes*.

120. *Escallonieæ*, R. Brown. Calyx superior, five-toothed; petals five, rising from the calyx, and by their cohesion forming a tube, but finally separating, with an imbricate æstivation; stamens rising from the calyx; anthers two-celled; disk conical, epigynous, plicate, surrounding the base of the style; ovarium inferior, two-celled, having two large polyspermous placentas in the axis; style simple; stigma two-lobed; fruit capsular, two-celled, crowned by the style and calyx, dehiscing from the separation of the cells at the base; seeds numerous, minute, covered by a transparent, membranous integument; albumen oily; embryo minute, located at the apex of the albumen; radicle pointing contrary to the hilum. Composed of shrubs or trees with alternate, simple leaves, which are full of resinous glands, and without stipulas; flowers axillary and terminal, beautiful. Distinguished from *Grossularieæ* by the cohering petals, oily albumen, situation of placentas, and by the radicle being contrary to the hilum. Examples, *Escallonia*, *Anopterus*, *Itea*, *Forgesia*.

121. *Canoniaceæ*, R. Brown. Calyx four to five-cleft, rarely six to ten-parted, with a valvate æstivation; petals equal in number to the divisions of the calyx; with an imbricate æstivation, rarely wanting; stamens inserted in a perigynous disk, usually definite, rarely indefinite; anthers peltate, two-celled; ovarium two-celled, containing many ovula; styles two, distinct, rarely combined; stigmas two, obtuse, pruinose; capsule composed of two conflated follicles, which are applied to each other, rarely confluent, two-celled, two-valved, usually ending in two beaks, many-seeded; dissepiments double, formed of the inflexed edges of the valves; placenta central, composed of fascicles of umbilical vessels; seeds pendulous, sometimes winged; albumen copious, fleshy; embryo straight, slender; radicle turned to the umbilicus. Composed of trees and shrubs, mostly natives of the southern hemisphere, with opposite or verticillate, simple or compound leaves; stipulas interpetiolar, rarely wanting; flowers generally disposed in spicate racemes or panicles. Distinguished chiefly by habit from *Saxifragaceæ*. Astringency is the only property of this order; it is divided into four tribes. Tribe 1. *Canonieæ*. Stamens definite; ovarium distinct. Examples, *Weinmannia*, *Canonia*, *Callicoma*, *Ceratopetalum*, and *Schizomeria*. Tribe 2. *Codieæ*. Stamens definite; ovarium inferior. Example, *Codia*. Tribe 3. *Bauereæ*. Stamens indefinite; ovarium free. Examples, *Bauera*, *Belangera*. Tribe 4. *Symphyogyneæ*. Stamens definite; ovarium free; styles connate. Example *Geissois*.

122. *Galacineæ*, D. Don. *Francoaceæ*, Adr. Jussieu. —Calyx four to five-parted, persistent; petals four to five, inserted at the very base of the calyx, almost hypogynous; stamens eight, ten or sixteen, almost hypogynous, inserted with the petals, distinct or combined into a tube, which is toothed at the apex, the alternate teeth alone antheriferous; ovarium composed of three to four combined follicles, therefore three to four-celled; ovula indefinite; stigma undivided, or three to four-lobed, capsule three to four-celled, three to four-valved; dissepiments intervalvular; central placenta none; seed numerous, minute, scaleform, inserted on the inner angles of the cells; outer testa loose, membranous; albumen copious, fleshy; embryo erect, terete; cotyledons short; radicle long, centripetal. Composed of perennial American herbs; leaves radical, simple, lyrate, pinnatifid or serrated, having the teeth each tipped by a gland; flowers terminal, numerous, disposed in racemes; pedicels one-flowered, propped each by a permanent bracteole. The presence of sterile stamens alternating with the fertile ones, the absence of a central placenta, and the quaternary arrangement of the parts of the calyx and corolla, distinguish it from its nearest ally *Saxifragaceæ*. Examples, *Galax*, *Francoa*, and *Tetilla*.

122. *Saxifragaceæ*, Jussieu. Calyx either superior or inferior, four to five-parted; petals five, rarely wanting, inserted between the calycine lobes; stamens five or ten, inserted either into the calyx or beneath the ovarium, therefore both perigynous and hypogynous; anthers two-celled disk hypogynous or perigynous, annular and notched, sometimes obsolete, rarely of five separate scales; ovarium inferior or nearly superior, consisting of two to five carpels, which cohere more or less on their inner sides, but distinct at their apices; either two-celled with a central placenta, or one-celled with parietal placentas, rarely four to five-celled; stigmas sessile on the tips of the lobes of the ovarium; fruit usually a one or two-celled, capsule propped by two bracteas, rarely a four to five-celled, four to five-valved capsule, or a four-celled berry; seeds numerous, minute; testa transparent; albumen

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fleshy; embryo terete in the axis of the albumen; radicle turned to the hilum. Composed of herbs and small shrubs, very variable in habit, with simple, divided, or entire, alternate leaves, without stipulas; flower-stems simple, often naked. Distinguished from *Cunoniaceæ* in habit, and by the want of stipulas; and from *Crassulaceæ* in the fewer carpels, and in being destitute of the glands on the inner sides of the carpels. Nearly allied to *Rosaceæ* in habit, but the albuminous seeds and want of stipulas is sufficient to distinguish them. Astringency is the only property of this order, which is divided into two tribes. Tribe 1. *Saxifrageæ*. Herbs. Examples, *Saxifraga*, *Chrysosplenium*, *Mitella*, *Tellima*, *Tiarella*, *Astilbe*, *Heuchera*. Tribe 2. *Hydrangeæ*. Shrubs. Examples, *Hydrangea*, *Adamia*, *Cornidia*.

123. *Bruniaceæ*, R. Brown. Calyx adhering to the ovarium, rarely free, five-cleft or five-toothed, with an imbricate æstivation; petals five, inserted in the ovarium, with an imbricate æstivation; stamens five, epigynous; anthers two-celled, bursting inwards; ovarium half inferior, three-celled; cells one to two-ovulate; ovula suspended from the central column; style simple or bifid; stigmas one, two, or three, small, papilliform; fruit dry, bicoccous, or indehiscent, one-seeded, inferior or half inferior; embryo placed at the apex of a fleshy albumen; radicle long, conical; cotyledons short. Composed of much branched, heath-like shrubs; leaves stiff, entire, arranged in five rows on the branches; flowers small, capitate, rarely panicled, spiked, or terminal and solitary; heads of flowers naked or involucrated with larger leaves, each flower tribracteate. Said to come very near to *Saxifragaceæ*. Examples, *Brunia*, *Linconia*, *Staavia*.

124. *Hamamelideæ*, R. Brown.—Calyx more or less four-lobed, or repandly toothed, its tube adhering to the ovarium; petals four, linear, elongated, inserted in the calyx, with an involutely valvate æstivation, rarely wanting; stamens short, inserted with the petals, and double their number; those opposite the petals destitute of anthers; anthers two-celled, dehiscing in various ways; ovarium half inferior, two-celled; ovula pendulous, solitary in the cells; styles two, rarely three; capsule two-celled, two-valved; valves bifid; seeds pendulous; hilum superior; albumen horny; embryo straight; radicle superior; cotyledons foliaceous, flat, or with involute edges. Composed of shrubs with alternate, bistipulate, entire or toothed leaves, and axillary, almost sessile, fascicles of flowers, which are usually bracteate; they are sometimes dioecious, and sometimes polygamous. According to Dr. Brown this order comes close upon *Bruniaceæ*: it is divided into two tribes. Tribe 1. *Hamameleæ*. Petals four; stamens eight, four of which are sterile; anthers dehiscing by a valve. Examples, *Hamamelis*, *Trichocladus*. Tribe 2. *Fothergilleæ*. Petals wanting; stamens twenty-four, all fertile; anthers dehiscing by a semicircular chink at the margin. Example, *Fothergilla*, *Sedgewickia*.

Third division. *Epipetalæ*, Jussieu. Stamens epigynous.

125. *Umbelliferæ*, Jussieu.—Limb of calyx entire or toothed; petals five, inserted in the top of the tube of the calyx, entire, emarginate, or two-lobed, each usually drawn out into a replicate or involute point, with a somewhat imbricate, rarely valvate æstivation, the outer flowers of the umbel often the largest; stamens five, inserted with the petals; anthers two-celled; ovarium inferior, two-celled; styles two, at length thickened at the base into what is called a stylopodium, which forms a sort of crown to the fruit; fruit consisting of two mericarps, separable from a common axis called a carpophore, to which they adhere by their faces, called the commissure; the whole fruit is traversed by ten elevated primary ridges, of which the five that represent the middle of the sepals are called carinal, because they extend into calycine teeth, and the other five are called sutural, because they lead to the recesses between the calycine teeth, and besides these are others intermediate between these ten primary ribs, called secondary ribs; all the ribs are either filiform, winged, or erested, and these again are separated by channels called valleculæ, below which, but usually in the channels, are placed in the substance of the pericarp certain linear receptacles of coloured, oily matter, called vittæ; these are either solitary, twin, or numerous, rarely wanting; seed solitary in each mericarp, hanging from the top of the carpophore, enclosed in a proper membrane, the spermaderm, which is but rarely separable from the pericarp; albumen large, fleshy, or horny, convex outside; embryo minute, hanging from the top of the carpophore; radicle superior; cotyledons oblong. Composed usually of herbs, rarely shrubs; leaves alternate, rarely opposite, variously compound; petioles sometimes changed into phyllodia as in the genus *Bupleurum*; flowers umbellate, of various hues, rarely unisexual; umbels generally perfect, both general and partial, in both the rays are numerous, the general umbel usually surrounded by an involucrum, and the partial ones by an involucel each. The order is readily distinguished, and never can be confounded with any other. The properties of the herbs are suspicious and sometimes poisonous, as the Hemlock, Fool's Parsley, Water Hemlock, and others; but nevertheless Celery, Parsley, Samphire, the roots of Carrot, Parsnip, and Arracacha, are wholesome articles of food. The seeds are seldom dangerous, and are usually warm and agreeably aromatic, as the Caraway, Anise, Dill, Coriander, &c.; of drugs, Gum Ammoniac, Gum Galbanum, Assafœtida, are produced by plants of this family. The famous fodder plant of Thibet, *Prangos*, is also of this order. The order is divided by Koch into several suborders and numerous tribes. Suborder 1. *Orthospermæ*. Albumen flat or flattish inside, neither involute nor convolute. This suborder is divided again into the following tribes, viz. Tribe 1. *Hydrocotyleæ*; 2. *Mulineæ*; 3. *Saniculeæ*; 4. *Ammineæ*; 5. *Seselineæ*; 6. *Angeliceæ*; 7. *Peucedaneæ*; 8. *Tordylineæ*; 9. *Silerineæ*; 10. *Cumineæ*; 11. *Thapsieæ*; 12. *Daucineæ*. Examples, *Hydrocotyle*, *Mulinum*, *Sanicula*, *Ammi*, *Seseli*, *Angelica*, *Peucedanum*, *Tordylium*, *Siler*, *Cuminum*, *Thapsia*, *Daucus*. Suborder 2. *Campylospermæ*. Albumen involute or marked by a longitudinal furrow or channel on the inner side; divided into the following tribes: 13. *Elæoselineæ*; 14. *Caucalineæ*; 15. *Scandicineæ*; 16. *Smyrneæ*. Examples, *Elæoselinum*, *Caucalus*, *Scandix*, *Smyrnium*. Suborder 3. *Cœlospermæ*. Albumen involutely curved from the base to the apex. This consists of a single tribe, *Coriandreæ*. Example, *Coriandrum*.

126. *Araliaceæ*.—Calyx having the tube adnate to the ovarium, and the limb entire or toothed; petals five or ten, with a valvate æstivation, rarely absent; stamens the same number as the petals, rarely double that number, inserted below the margin of a large epigynous disk; anthers peltate, two-celled; ovarium inferior, of two or more cells; ovula solitary in the cells; styles many, distinct, rarely joined or wanting; stigmas simple; berry two to fifteen-celled, crowned by the limb of the calyx; cells equal in number to the stigmas, one-

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seeded; seed angular, erect; embryo small, inverted in the axis of the fleshy albumen; radicle superior, long. Composed of shrubs, rarely herbs; stems often scandent, adhering by fibres to other substances, as the Ivy; leaves alternate, simple, or compound, without stipulas, and having the petioles always dilated and thickened at their bases; flowers axillary or terminal, umbellate or capitate; the umbels or heads often disposed in racemes or panicles, having involucels generally present. This order is nearly allied to *Umbelliferæ*, but differs in the inflorescence being more imperfectly umbellate, in the styles being generally numerous, in the fruit being baccate, generally many-celled, and always without vittæ, and in the parts of the fruit not being separable, in the albumen being fleshy, and in the embryo being nearly the length of the albumen. The bark of several species exudes an aromatic gum resin. The roots are tonic, such is the famous Ginseng, a species of *Panax*. Examples, *Adoxa*, *Panax*, *Gussonia*, *Gastonia*, *Aralia*, *Sciadophyllum*, *Hedera*.

127. *Corneæ*, De Candolle.—Calyx with the tube adhering to the ovarium, and the limb superior and four lobed; petals four, broadest at their bases, inserted in the upper part of the calycine tube, with a valvate æstivation; stamens four, inserted with the petals; anthers ovate-oblong, two-celled; style filiform; stigma simple; drupe baccate, crowned by the vestiges of the calyx, enclosing a two-celled nut; seed pendulous, solitary in the cells; albumen fleshy; embryo with a superior radicle which is shorter than the oblong cotyledons. Composed of trees and shrubs, rarely herbs; leaves opposite, except in one species of *Cornus*, entire or toothed; flowers capitate, umbellate or corymbose, naked or involucrated, rarely unisexual by abortion; pulp of fruit edible in some species. This order differs from *Caprifoliaceæ*, tribe *Sambuceæ*, in the corolla being polypetalous, in the quaternary arrangement of the parts of the flower, in the presence of a style, and in the stigmas being two, not three, and in the drupaceous, not baccate, fruit. It differs from *Loranthaceæ* in the stamens being alternate with the petals, not opposite them. Astringency is the principal property of the plants of this order, so much so, that the bark of some species is used for the purposes of Quinquina. Examples, *Cornus*, *Benthamia*.

128. *Loran'thaceæ*, Richard.—Flowers hermaphrodite or unisexual; calyx girded at the base by a calyculus, adnate to the ovarium, entire or lobed; petals four to eight, distinct or cohering more or less, with a valvate æstivation; stamens four to eight, opposite the petals, more or less adnate to the corolla; anthers oscillatory or erect, terminal; but when there are no filaments they are adnate to the lobes of the corolla; ovarium adnate to the calyx, ovate or turbinate; style filiform or wanting; stigma capitate; berry one-celled, one-seeded, ombilicated by the calyx; albumen fleshy; radicle superior, thickened or truncate at the apex. Composed of shrubs, which are generally parasitical, and derive their nourishment from other trees, on which they grow, like the Mistletoe; a very few of them being terrestrial; leaves opposite, rarely alternate or wanting, coriaceous, quite entire; the habit and disposition of the flowers are very variable. The common Mistletoe, *Viscum album*, also the Mistletoe of the Druids, *Loranthus Europæus*, are of this order. The latter is conjectured to have formerly existed in this country, but is said to have disappeared on the extirpation of the Druids. Distinguished from *Caprifoliaceæ* and *Corneæ* by the habit, and by the stamens being opposite the petals. Examples of the parasitical genera, *Viscum*, *Loranthus*, &c., of the terrestrial genera, *Gaiadendron*, *Nuytsia*, *Aucuba*.



129. *Caprifoliaceæ*.—Tube of calyx adnate to the ovarium, limb free, five-lobed; corolla monopetalous, perigynous, with a short tube and a five-lobed limb, with a valvate or irregular æstivation; stamens perigynous, but adnate to the corolla at their bases, five in number, alternating with the lobes of the corolla, enclosed or exserted; anthers ovate, two-celled; ovarium inferior, three-celled while young; style exserted, seldom wanting; stigmas three, distinct, or combined into a head; berry crowned by the calycine limb, pulpy, rarely dry, many-celled, but often one-celled, from the dissepiments having vanished; seeds inverted, solitary, twin, or numerous in each cell; albumen fleshy; embryo central; radicle superior; cotyledons ovate-oblong. Composed mostly of shrubs, rarely herbs or trees; leaves opposite, generally without stipulas, rarely furnished with two small ones at the bases of the petioles, simple, undivided, toothed, rarely pinnate; flowers terminal, corymbose, or axillary. *Lonicera*, or Honeysuckle, is the type of this order, which agrees with *Loranthaceæ* in the structure of the flowers and berries, and sometimes in habit. In habit, also, this order tends towards *Umbelliferæ*, through *Sambucus*. *Triosteum* and *Leycesteria* appear to be a link between it and *Rubiaceæ*. Astringency is the principal property of this order. *Triosteum*, or Tinker's Weed, is a mild cathartic. The order is divided into two tribes. Tribe 1. *Sambuceæ*. Corolla regular, rotate, rarely tubular; stigmas three, sessile. Examples, *Sambucus* and *Viburnum*. Tribe 2. *Loniceræ*. Corolla more or less tubular, usually irregular; style filiform, crowned by three distinct or concrete stigmas. Examples, *Triosteum*, *Diervilla*, *Lonicera*, *Symphoricarpus*, *Leycesteria*, *Abelia*, and *Linnæa*.

130. *Rubiaceæ*, Jussieu.—Calyx with the tube adhering to the ovarium and the limb variable, truncate, or of many lobes, usually regular; corolla monopetalous, inserted in the upper part of the tube of the calyx, usually with a four to five-lobed, rarely with a three to nine-parted limb, with a twisted or valvate æstivation; stamens equal in number to the segments of the corolla, more or less adnate to its tube; anthers two-celled, dehiscing inwards; ovarium adhering to the tube of the calyx, two to many-celled, rarely one-celled, always crowned by the fleshy urceolus or limb of the calyx; style one; stigmas usually two, rarely more, distinct, or more or less combined; fruit baccate or capsular; cells one, two, or many-seeded; seeds, when solitary in the cells, fixed to the base or apex, but when numerous fixed to the central placenta, then horizontal; albumen horny or fleshy; embryo straight, or a little curved in the centre of the albumen; radicle terete, turned to the hilum; cotyledons foliaceous. Composed of trees, shrubs, and herbs; leaves simple, girded by a marginal nerve, quite entire, opposite, or verticillate; stipulas variable in cohesion and form, intrapetiolar or intrafoliaceous; flowers arranged in various ways, but generally in panicles or corymbs, rarely unisexual by abortion. The inferior ovarium, æstivation of corolla, opposite leaves, and intervening stipulas distinguish this order from all others. The properties are febrifugal, as Peruvian Bark, or emetic, as Ipecacuanha. *Genepa Voavanga* and African Peach are among the edible fruits of this family. Coffee is the seeds of *Coffea Arabica*,

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This extensive family is divided into many tribes. Tribe 1. *Cinchonaceæ*. Fruit capsular, two-celled, many-seeded; seeds winged; stipulas interpetiolar. Trees and shrubs. Examples, *Nauclea*, *Cinchona*. Tribe 2. *Gardeniaceæ*. Fruit indehiscent, fleshy, two, rarely one-celled; seeds numerous, not winged. Trees and shrubs. Leaves opposite; stipulas interpetiolar. Examples, *Sarcocephalus*, *Burchellia*, *Gardenia*, *Catesbæa*. Tribe 3. *Hedyotideæ*. Fruit capsular, two-celled, loculicidal or indehisceot, many-seeded; seeds not winged. Shrubs or herbs. Leaves opposite; stipulas interpetiolar. Examples, *Rondeletia*, *Hedyotis*, *Oldenlandia*. Tribe 4. *Isertieæ*. Fruit drupaceous, composed of two to six many-seeded cocculi. Shrubs or herbs. Leaves opposite; stipulas interpetiolar. Example *Isertia*. Tribe 5. *Hamelieæ*. Fruit baccate, many-celled, many-seeded. Trees and shrubs. Leaves opposite or verticillate; stipulas interpetiolar. Example, *Hamelia*. Tribe 6. *Cordiereæ*. Fruit baccate, many-celled; cells one-seeded. Shrubs with opposite leaves and interpetiolar stipulas. Example, *Cordiera*. Tribe 7. *Guettardaceæ*. Fruit drupaceous, containing two to five one-seeded nuts; seeds usually erect. Trees or shrubs. Leaves opposite, or three in a whorl; stipulas interpetiolar. Tribe 8. *Pæderieæ*. Fruit two-celled, indehiscent, hardly fleshy; the rind easily separated from the carpels, which are compressed and one-seeded, and hang from a filiform axis. Climbing shrubs. Leaves opposite; stipulas interpetiolar. Example, *Pæderia*. Tribe 9. *Coffeaceæ*. Fruit two-celled, baccate, containing two one-seeded bony nuts, which are flat and marked by a furrow inside. Trees or shrubs. Leaves opposite; stipulas interpetiolar, two on each side, combined or distinct. Examples, *Coffea*, *Ixora*, *Psychotria*, *Cephælis*. Tribe 10. *Spermacoceæ*. Stigma bilamellate; fruit dry or rather fleshy, composed of two one-seeded mericarps, rarely three to four, which are either separate or combined, indehiscent or dehiscent. Shrubs or herbs. Leaves opposite; stipulas usually divided into bristles at their apices. Examples, *Cephalanthus*, *Spermacoce*, *Serissa*. Tribe 11. *Anthospermeæ*. Corolla rotate; styles two, ending each in a plumose stigma; fruit composed of two indehiscent, one-seeded mericarps. Herbs or shrubs. Leaves opposite or in whorls; stipulas small, one to two-toothed, rather adnate to both sides of the petiole. Examples, *Coprosma*, *Phyllis*. Tribe 12. *Stellatæ*. Corolla rotate or funnel-shaped; styles two; stigmas capitate; fruit composed of two one-seeded, indehiscent mericarps. Usually herbs. Leaves and stipulas in whorls of the same shape. Examples, *Sherardia*, *Asperula*, *Rubia*, *Galium*, *Vaillantia*. Tribe 13. *Opercularieæ*. Fruit one-celled, one-seeded, joined into a head, dehiscing by two valves at the apex. Shrubs or herbs. Leaves opposite; stipulas twin on both sides, distinct or combined. Examples, *Opercularia*, *Lipostoma*.

131. *Valerianeæ*, De Candolle. Calyx having its tube adhering to the ovarium; limb variable in the different genera, toothed or parted, and sometimes changed into pappus; corolla funnel-shaped, five-lobed, rarely three or four-lobed; tube equal, gibbous, or spurred at the base; stamens adnate to the corolla at the base, one to five in number, when equal to the lobes alternating with them; anthers ovate, two-celled; style filiform, crowned by two or three free or combined stigmas; fruit membranous or subnucamentaceous, indehiscent, crowned by the limb of the calyx, one or three-celled, when the latter is the case two of the cells are empty; seed pendulous; albumen none; embryo straight; radicle superior; cotyledons flat. Composed of annual or perennial herbs; leaves opposite without stipulas, different in divers species, and sometimes in the same plant; flowers disposed in cymose corymbs, rarely unisexual by abortion, each furnished with one or three bracteas. The species of *Valerianella* are used in salads. The *Valeriana officinalis* and some others are bitter, tonic, aromatic, and vermifugal. The roots of the Celtic Spikenard, *Valeriana Celtica*, are used to perfume baths in eastern countries; and in India the *Nardostachys* or Ancient Spikenard is used as a perfume. Examples, *Patrinia*, *Valerianella*, *Fedia*, *Plectritis*, *Centranthus*, and *Valeriana*.

132. *Dipsaceæ*, Vaillant. Tube of calyx adnate to the ovarium; limb variable, short, or elongated, entire, toothed, or ending in numerous variable bristles which are usually plumose, or pappus-formed; corolla monopetalous, inserted near the top of the calycine tube, usually unequal, but rarely ringent, four to five-cleft; stamens four, inserted in the tube of the corolla, alternating with its lobes; anthers two-celled; style filiform; stigma longitudinal or capitate, always simple; fruit indehiscent, membranous, or subnucamentaceous; crowned by the calycine limb, one-celled, one-seeded, usually covered by an involucel; seed pendulous; albumen fleshy; embryo straight; radicle superior. Composed of herbs or undershrubs, with opposite rarely verticillate leaves, which are variable in turn even on the same plant; the radical ones being always different from the cauline ones. Flowers disposed in dense heads girded by involucra, rarely in whorls; having a calyciform involucel girding each flower. The involucrated heads, involucelled flowers, and free stamens separate it from *Calycereæ* and *Compositæ*, its nearest allies, also from the latter order in the albuminous seeds.

Sixth division, *Epicorollæ-Synantheræ*, Jussieu. Corolla epigynous; anthers combined or joined.

133. *Calycereæ*, R. Brown. Calyx of five unequal segments; corolla funnel-shaped, regular; tube slender; segments five, three-nerved; glandular spaces below the stamens and alternating with them; stamens five, monadelphous; anthers combined by their lower half; ovarium inferior, one-celled; style clavate above; stigma capitate, simple; achenia indehiscent, crowned by the stiff, spine-like segments of the calyx; seeds solitary, inverted; albumen fleshy; embryo in the axis, slender. Composed of herbs, with alternate, exstipulate leaves; and having the flowers collected into heads surrounded by involucra, and with bracteas among the flowers; they are sessile and either hermaphrodite or unisexual; the heads terminal or opposite the leaves. This order differs from *Compositæ* in the albuminous pendulous ovulum, and by the anthers being only partly combined; and from *Dipsaceæ* in the monadelphous filaments and combined anthers. Examples, *Calycera*, *Boopis*, and *Acicarpha*.

134. *Compositæ*, Adanson. Limb of calyx wanting or membranous, and divided into bristles, paleæ, or hairs, which are called the pappus; corolla five-toothed or five-lobed, tubular, ligulate, or bilabiate, on the top of the ovarium, with a valvate æstivation; stamens five, distinct; anthers combined, rarely free, erect, articulated with the filaments; ovarium cohering to the calycine tube, one-celled, containing a single erect ovulum; style one; stigmas two, distinct or united;



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fruit an achenium crowned by the limb of the calyx; seed solitary, erect; albumen none; radicle inferior. Composed of herbs and shrubs, inhabiting all parts of the world. Leaves alternate or opposite, without stipulas, generally simple, and often lobed. Flowers hermaphrodite or unisexual, disposed in heads on a receptacle, which is surrounded by a many-leaved involucrum, the scales of which are sometimes mixed with the flowers on the receptacle, and are then called paleæ. The properties are sudorific, diuretic, tonic, febrifugal, anthelmintic, and antispasmodic. Jerusalem Artichoke, Lettuce, Salsify, and others, are among the esculents furnished by this order, and Dahlias, Chrysanthemums, Daisies, and Marigolds are favourite flowers. This most extensive order is characterised by the cohesion of the anthers, the arrangement of the flowers in involucrated heads on a receptacle. The following arrangement of this order has been adopted by Lessing and De Candolle. The tribes given are again subdivided in several subtribes. Division 1. *Tubuliflorœ*. Hermaphrodite flower tubular, regularly five-toothed, rarely four-toothed. Tribe 1. *Vernoniaceœ*. Style of hermaphrodite flower cylindrical, having its branches usually subulate and elongated, rarely short and blunt, always equally hispid, series of stigmas ending before the middle of the branches of the style. Example, *Vernonia*. Tribe 2. *Eupatoriaceœ*. Style of hermaphrodite flower cylindrical, having its branches long, subclavellate, puberulously papillose above on the outside; series of stigmas rather prominent, usually ending before the middle of the branches of the style. Example, *Eupatorium*. Tribe 3. *Asteroideœ*. Style of hermaphrodite flower cylindrical, having its branches linear and flattish, equally and minutely puberulous above; series of stigmas rather prominent, extended even to the origin of the exterior down. Examples, *Aster, Solidago*. Tribe 4. *Senecionidœ*. Style of hermaphrodite flower cylindrical, having its branches linear and pencilled at top, sometimes truncated, and sometimes drawn out into a short cone, or narrow, elongated, hispid appendage beyond the pencilled part; series of stigmas broadish, rather prominent, and even extended to the pencil. Example, *Senecio*. Tribe 5. *Cynareœ*. Style of hermaphrodite flower nodosely thickened above, and often pencilled at the nodi; having its branches sometimes concrete and sometimes free, puberulous outside; series of stigmas not in any way prominent, attaining the tops of the branches, and there confluent. Example, *Cynara*. Division 2. *Labiatiflorœ*. Hermaphrodite flowers generally bilabiate. Tribe 6. *Mutisiaceœ*. Style of hermaphrodite flower cylindrical, or somewhat nodose above, having its branches generally blunt or truncate, convex outside, clothed in the upper part by minute equal down, which is rarely absent. Example, *Mutisia*. Tribe 7. *Nassauviaceœ*. Style of hermaphrodite flower never nodosely thickened; having its branches linear, longish, and truncate, pencilled only at the apex. Division 3. *Liguliflorœ*. All the hermaphrodite flowers ligulate. Tribe 8. *Cichoraceœ*. Style cylindrical above, having its branches rather long and bluntish, and equally pubescent; series of stigmas ending before the middle of the branches of the style. Examples, *Cichorium, Hieracium, Crepis, Scorzonera*.

Seventh division. *Pericorollœ*, Jussieu. Corolla perigynous.

135. *Lobeliaceœ*, Jussieu. Calyx superior, with a five-toothed or five-parted, rarely an entire, limb; corolla monopetalous, irregular, inserted in the calyx; limb five-lobed or five-cleft; stamens five, inserted in the calyx; anthers cohering; ovarium inferior, usually two-celled, rarely one to three-celled; ovula numerous, attached to the axis or parietes of the fruit; style simple; stigma usually two-lobed, surrounded by a cuplike fringe; fruit capsular or baccate, one to two-celled, very rarely three-celled, many-seeded, dehiscing at the apex; albumen fleshy; embryo straight in the axis; radicle pointing to the hilum. Composed usually of herbs, rarely undershrubs, with alternate leaves without stipulas, and axillary and terminal flowers of various hues. This order comes nearer to *Goodenoviœ* than to any other, by the irregular flowers, cohering anthers, and in the stigma being surrounded by a fringe, which is probably analogous to the indusium of the stigma in that order. The plants of this family yield an acrid milky juice which is dangerous; *Hippobroma* is one of the most poisonous of plants. The species are all ornamental. Examples, *Tupa, Pratia, Siphocampylus, Lobelia, Dortmanna, Parastranthus, Monopsis, Clintonia, Canonanthus, Isotoma*.

136. *Stylideœ*, R. Brown. Calyx superior, two to six-parted, bilabiate or regular, permanent; corolla monopetalous, limb five to six-cleft, irregular, rarely equal, deciduous, with an imbricate æstivation; stamens two, combined into a column along with the style; anthers didymous, seldom simple, lying upon the stigma; ovarium two-celled, but when the dissepiment is short it is nearly one-celled, furnished with a gland in front, or crowned by two opposite glands; style simple; stigma undivided or bifid; capsule many-seeded, two-valved, two-celled, with a parallel dissepiment, or nearly one-celled from the dissepiment being short; seeds fixed to the axis of the dissepiment, small, erect, sometimes pedicellate; albumen fleshy or oily; embryo minute, enclosed. Composed of nonlactescent herbs or undershrubs. Leaves usually scattered, but sometimes verticillate, entire, with naked or ciliated edges; the radical leaves crowded in the scapigerous species. Flowers spicate, racemose, corymbose, and solitary, terminal, rarely axillary; pedicels generally tribracteate. Nearly allied to *Campanulaceœ* and *Goodenoviœ*, but is readily distinguished from both by the gynandrous stamens, and also from the latter in the want of the indusium to the stigma. The stamens and style are combined into a solid, irritable column, at the top of which is a cavity enclosing the stigma and bounded by the anthers. Examples, *Stylidium, Levenhookia*.

137. *Goodenoviœ*, R. Brown. Calyx superior or semisuperior, persistent, limb usually five-cleft, sometimes five to three-parted, or obsolete, equal, rarely unequal; corolla monopetalous, irregular, deciduous, or marcescent; limb five-parted, bilabiate, or unilabiate, with an induplicate æstivation; stamens five, distinct; anthers free or cohering, two-celled; ovarium furnished with a gland between the two anterior filaments; style simple, rarely divided; stigma fleshy, obtuse, or two-lobed, girded by a membranous, entire, or two-lobed, cup-shaped indusium; capsule two-celled or half two-celled, rarely four-celled; dissepiment usually parallel, rarely contrary to the valves, having the axis bearing the seeds; albumen fleshy; embryo erect; cotyledons foliaceous. Composed of nonlactescent herbs or undershrubs. Leaves scattered, exstipulate, simple, usually undivided, lobed, or toothed. Flowers terminal and axillary, vari-

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able, distinct, yellow, blue, or purple. This order is nearly allied to *Campanulaceæ* and *Lobeliaceæ*, but differs from them in the æstivation of the corolla, and by the peculiar indusium to the stigma; it is divided into three tribes. Tribe 1. *Goodenieæ*. Seeds indefinite. Examples, *Goodenia*, *Euthales*, *Velleia*, *Lechenaultia*. Tribe 2. *Scævoleæ*. Seeds definite; drupe inferior. Examples, *Scævola*, *Dampiera*. Tribe 3. *Campanieæ*. Corolla regular; capsule three to four-celled, many-seeded; Indusium three-lobed. Example, *Pentaphragma*.

138. *Brunoniaceæ*, R. Brown. Calyx five-parted, persistent, furnished with four bracteas at the base; tube short, at length enlarged; corolla inserted in the very base of the calyx, monopetalous, funnel-shaped, almost regular, marcescent; limb five-parted, having the two superior segments more deeply divided than the rest, with a valvular æstivation; stamens five, inserted with the corolla, having distinct filaments and combined two-celled anthers; ovarium superior or free, one-celled; ovulum solitary, erect; style simple; stigma enclosed in a two-valved indusium; fruit or utricle enclosed within the indurated tube of the calyx; albumen none; embryo straight; radicle small, inferior; cotyledons fleshy, plano-convex. Composed of Australian herbs without stems, with the habit of *Jasione*, or *Globularia*. Leaves radical, without stipulas; scapes bearing each a head of blue flowers, which is involucrated by large bracteas. This order agrees with *Goodenoviæ* in the indusium to the stigma, but differs from it in the fruit being a superior one-seeded utricle, and in habit. Example, *Brunonia*.

139. *Campanulaceæ*, Jussieu. Calyx from three to eight-lobed, but usually five-lobed; corolla monopetalous, regular, permanent; limb usually five-lobed, rarely three to eight-lobed, with a valvate æstivation; stamens inserted along with the corolla on the margin of the disk of the ovarium, and combined with it, but distinct from the corolla, and equal in number to its segments, usually five; filaments flattened; anthers fixed by their bases, contiguous, but free, rarely combined, two-celled; style simple; stigma usually divided into from two to eight lobes, which are at length recurved, rarely capitate; ovarium superior, rarely half superior, two to eight-celled, but usually five-celled; capsule many-seeded, dehiscing at the sides or apex, the valves usually septiferous in the middle; seeds numerous, small, inserted in the placentas on the inner sides of the cells; albumen fleshy; embryo straight, slender. Composed of milky herbs, rarely shrubs. Leaves usually alternate, rarely opposite, generally toothed or crenated, rarely entire, without stipulas; the radical ones often different from the cauline ones in form; inflorescence terminal and axillary, variably disposed, racemose, panicled, spicate, or glomerate, usually drooping; corollas blue, purple, and white, rarely yellow. *Campanulaceæ* is distinguished from *Goodenoviæ* and *Brunoniaceæ* in the want of the indusium to the stigma, and in the anthers being generally distinct, and in the corollas being regular, &c. The order is divided into two tribes. Tribe 1. *Jasioneæ*. Capsule dehiscing at the apex. Examples, *Jasione*, *Lightfootia*, *Canarina*, *Platycodon*, *Wahlenbergia*, *Prismatocarpus*, and *Roella*. Tribe 2. *Campanuleæ*. Capsule dehiscing at the sides. Examples, *Phyteuma*, *Michauxia*, *Campanula*, *Specularia*, *Trachelium*, *Adenophora*, *Symphyandra*, *Muschia*.

140. *Epacrideæ*, R. Brown. Calyx five-parted, rarely four-parted, persistent; corolla hypogynous, monopetalous; limb five-cleft, rarely four-cleft, equal, deciduous, or marcescent, with a valvate or imbricate æstivation; stamens five, rarely four, epipetalous or hypogynous; anthers simple, one-celled; ovarium usually girded by five distinct or combined scales, usually many-celled, rarely one-celled; seeds solitary or indefinite; style single; stigma sometimes toothed; fruit drupaceous, baccate, or capsular; seeds albuminous; embryo straight, slender. Composed of elegant shrubs and small trees of a dry prickly habit, with tubular or campanulate flowers, which are either axillary and solitary, or disposed in terminal spikes or racemes; corollas white or purple, rarely blue. This family is chiefly distinguished from the next in the one-celled awnless anthers. It is divided into two tribes. Tribe 1. *Staphylieæ*. Cells of ovarium one-seeded; pericarp fleshy, rarely capsular. Examples, *Styphelia*, *Astroloma*, *Stenanthera*, *Lissanthe*, *Leucopogon*, *Acrotriche*, *Trochocarpa*, &c. Tribe 2. *Epacrieæ*. Cells of ovarium many-seeded; pericarp capsular. Examples, *Epacris*, *Lysinema*, *Andersonia*, *Ponceletia*, *Sprengelia*, *Richea*, *Dracophyllum*, *Sphenotoma*.

141. *Ericaceæ*, D. Don. Flowers hermaphrodite, subsymmetrical, regular; calyx four or five-cleft; corolla four-parted, rarely five-parted; stamens four, five, eight, or ten, their insertion various; anthers two-celled; style and stigma undivided; capsule free, or adhering to the fleshy calyx, therefore baccate; cells usually many-seeded; albumen fleshy; embryo erect, slender. This order is composed of shrubs variable in habit which are scattered over the surface of the earth in every direction. Few families surpass the *Ericaceæ* in the diversities of their forms, beauty of their flowers, or in the extent of their geographical distribution, which verges upon the ultimate limits of vegetation in both hemispheres. The fruit of several species is eatable, as the Whortleberry, *Gaultheria Shallon*, Cranberry, &c. The order is divided into the following tribes. Tribe 1. *Ericeæ*. Ovarium free; hypogynous disk nectariferous; buds naked; margins of leaves usually revolute. Examples, *Erica*, *Andromeda*, *Arbutus*, *Gaultheria Epigæa*, *Clethra*. Tribe 2. *Rhodoreæ*. Ovarium free; hypogynous scales nectariferous; buds strobile-formed, scaly; leaves flat, and callous at the extremity of the midrib. Examples, *Rhododendron*, *Kalmia*, *Azalea*, *Ledum*. Tribe 3. *Vaccinieæ*. Ovarium adherent; disk perigynous, nectariferous; fruit baccate. Examples, *Vaccinium*, *Oxycoccus*. Tribe 4. *Pyroleæ*. Ovarium free; disk hypogynous, naked; seeds peltate, samaroid. Perennial herbs. Examples, *Pyrola*, *Chimophila*. Tribe 5. *Monotropeæ*. Ovarium free; disk hypogynous, naked; seeds peltate; embryo undivided. Leafless, parasitical herbs. Examples, *Monotropa*, *Hypopitys*.

142. *Columelliaceæ*, D. Don. Calyx five or many-parted, persistent, more or less adnate to the ovarium; corolla inserted in the upper part of the calycine tube, rotate, or funnel-shaped; limb five-lobed, with a convolutely imbricate æstivation; stamens two, inserted in the thickened part of the throat, short and dilated; ovarium inferior, or half inferior, two-celled, containing many ovula; style declinate, on a flat, fleshy disk; stigma capitate, convex at top; capsule two-celled, two-valved, dehiscing by a cross-like chink at top, many-seeded; albumen fleshy, or wanting. Composed of trees or shrubs with opposite, petiolate, entire leaves, and



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yellow or white terminal flowers, similar to those of the Jessamine. An adherent ovarium, the presence of a perigynous disk, undivided stigma, inferior capsule, and many-seeded cells, separate this order from its nearest allies *Jasmineaceæ* and *Oleinæ*. Examples, *Columellia*, *Bolivaria*, and *Menodora*.

143. *Symplocineæ*, D. Don.—Calyx five-parted; corolla monopetalous, rotate; limb five or ten-parted, spreading, when more than five, the half of them are interior and smaller, with an imbricate æstivation; stamens numerous, rising from the tube of the corolla, disposed in three or four series or rows; filaments cuspidate at apices and polyadelphous at their bases; anthers erect, roundish-elliptic, two-celled; ovarium half inferior, three or five-celled; ovula four in each cell, fixed to the inner parietes of the cells, the two lower ones pendulous; style crowned by a three or five-lobed stigma; drupe rather fleshy, crowned by the calyx, containing a three or five-celled nut; cells one-seeded; seeds bony, albuminous; embryo inverted; radicle superior. Composed of trees with alternate, entire, or serrulated leaves, without stipulas; flowers axillary, sessile, or pedicellate, solitary, crowded or racemose, furnished with imbricating bracteas at their bases. Astringency is the only property known of this order. The *Lohd*, *Symplocos racemosa*, is used with Mungeet for dyeing red in the East Indies. The leaves of *Symplocos tinctoria*, the Sweet-leaf, is used in America for dyeing yellow.

Third subclass. *Corollæfloræ*.—Corolla monopetalous, hypogynous, that is not attached to the calyx. To this subclass are to be referred all those plants with a monopetalous, hypogynous corolla, having the stamens inserted into it, and a superior ovarium; but those plants with a monopetalous, perigynous corolla having the stamens inserted into it, and an inferior ovarium, as *Rubiaceæ*, *Ericaceæ*, *Campanulaceæ*, *Lobeliaceæ*, *Caprifoliaceæ*, *Symplocineæ*, and *Columelliaceæ*, are still retained in the class *Calycifloræ*. In *Brunoniaceæ*, and some genera of *Ericaceæ*, where the ovarium is superior, or nearly so, it is sometimes difficult to draw a distinction, except probably from the perigynous insertion of the corolla.

144. *Halesiaceæ*, D. Don.—Calyx small, four-toothed; corolla ventricosely campanulate, four-lobed; stamens twelve to sixteen, monadelphous at their bases, and adnate to the corolla; anthers oblong, erect, two-celled; ovarium inferior; style and stigma simple; drupe dry, corticate, oblong, with two or four-winged angles, containing a two or four-celled putamen; cells one-seeded; seed attached to the bottom of the cell; albumen fleshy; embryo length of albumen; cotyledons narrow; radicle slender, inferior, compressed. Composed of trees with alternate, serrated leaves, and lateral fascicles of pedicellate, drooping, white flowers. Differs from *Symplocineæ* in the inferior ovarium, in the fruit being a dry winged nut, and in the corolla not being so deeply divided. Example, *Halesia*, the Snowdrop tree.

145. *Styracineæ*, Richard.—Calyx campanulate, five-toothed, persistent; corolla funnel-shaped, usually five or six-cleft, seldom three or seven-cleft, with a valvate æstivation; stamens ten, exserted, monadelphous at their bases, adnate to the tube of the corolla; anthers linear, two-celled; ovarium superior, three-celled, containing many erect ovula; style crowned by an obsoletely, three-lobed stigma; drupe almost dry, containing a one-celled, one to three-seeded nut; embryo inverted; radicle thick, superior; albumen fleshy. Composed of trees and shrubs which are usually clothed with stellate tomentum, bearing alternate, entire leaves without stipulas, and axillary or terminal, one or many-flowered peduncles; flowers racemose, bracteate, white or cream-coloured. Nearly allied to *Halesiaceæ*, but differs in the superior ovarium and more deeply divided corolla. *Styrax benzoin* affords the fragrant resin of that name, and *Styrax officinale* the storax of the shops.



146. *Myrsineaceæ*, R. Brown.—Calyx four to five-lobed, persistent; corolla four to five-lobed; stamens four to five, opposite the lobes of the corolla, and inserted in its base, free or monadelphous; ovarium superior, rarely half inferior; ovula immersed in the central placenta; style one; drupe or berry one or many-seeded; albumen horny, rarely deficient; cotyledons short. Composed of trees and shrubs; leaves alternate, seldom nearly opposite or verticillate, simple, entire, or toothed; flowers axillary, pedunculate, or sessile. All parts, but more especially the calyces and under surfaces of the leaves, are furnished with resinous dots. This family differs from *Sapotaceæ*, its nearest ally, in the stamens being opposite the petals, and in the structure of the seeds. It is divided into three tribes. Tribe 1. *Ægiceræ*. Flowers pentamerous; filaments monadelphous; ovarium superior, many-seeded; drupe follicular, one-seeded; albumen none; embryo erect. Example, *Ægiceras*. Tribe 2. *Ardisiæ*. Calyx and corolla four to five-lobed; stamens generally free; ovarium superior, many-seeded; berry globose, one-seeded; albumen horny; embryo transverse. Examples, *Myrsine*, *Ardisia*, *Embelia*. Tribe 3. *Mæsæ*. Calyx and corolla five-lobed; stamens five, free; ovarium half inferior, many-seeded; stigma three to five-lobed; embryo transverse. Example, *Mæsa*.

147. *Theophrastaceæ*, Bartling.—Calyx five-parted, persistent, imbricate; corolla five-lobed, with an imbricate æstivation, having scaleformed appendages alternating with the lobes; stamens five, opposite the lobes of the corolla; anthers two-celled, turned outwards; ovarium superior, one-celled; ovula, erect, indefinite, inserted in the central placenta; stigma simple, undivided; berry crustaceous, one-celled, valveless, one or many-seeded, filled by the fleshy placenta; umbilicus of seed hollow; testa of seed simple; albumen horny; embryo erect; cotyledons foliaceous; radicle opposite the hilum. Composed of small trees or shrubs with generally simple stems, bearing leaves at their tops; leaves alternate, callous, and usually toothed on the margins; flowers terminal and lateral, racemose. The scaleformed appendages between the petals are sufficient to distinguish this order from all its allies, and particularly from *Myrsineaceæ*, to which it comes very close. Examples, *Jacquinia*, *Clavija*, and *Theophrasta*.

148. *Ægicereæ*, Blume.—Calyx five-parted, persistent; lobes twisted to the left and imbricated in æstivation; corolla monopetalous, hypogynous, five-cleft, imbricated to the right in æstivation; stamens five, opposite the segments of the corolla, combined into a tube at the base, which adheres to the bottom of the corolla; anthers incumbent, two-celled; cells dehiscing lengthwise, but intercepted by transverse septula; ovarium superior, one-celled; ovula many, peltate, immersed in the free central placenta; style subulate; stigma simple; fruit follicular, cylindrical, arched, coriaceous, one-seeded; albumen none; embryo germinating within the pericarp, green, conforming to the fruit; cotyledons plano-convex, thick; radicle inferior, blunt; plumule awl-shaped, undivided. Composed of shrubs, natives of tropical Asia, on the seashore among Mangroves;

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leaves scattered, quite entire, full of immersed, glandular dots on the opper surface, and marked by a saline excretion; umbels simple, axillary, and terminal; flowers white, fragrant; pedicels articulated at their bases. Example, *Ægiceras*.

149. *Sapotaceæ*, Jussieu.—Calyx regular, persistent; corolla with as many lobes as there are divisions of the calyx, rarely double or triple that number, deciduous; stamens epipetalous, distinct, definite; fertile ones equal in number to the segments of the calyx, rarely more numerous, alternating with the segments of corolla; sterile ones, when present, equal in number to the fertile ones, and alternating with them; anthers usually outwardly or behind; ovarium superior, many-celled; cells one-seeded; ovola erect; style crowned by an undivided or lobed stigma; berry many-celled, or only one-celled by abortion; seeds nucumeotaceous, seldom combined into a many-celled putamen; testa bony, shining, having the front scraped away, and opaque; albumen fleshy, rarely wanting; embryo large; radicle pointing to the hilum. Composed of trees generally abounding in milky juice; leaves alternate, without stipulas, quite entire, coriaceous; flowers axillary. This order is nearly allied to *Ebenaceæ*, but differs in many particulars. The trees are chiefly valued for their fruit, as the Star Apple, *Sapota*, *Mammee-sapota*, and the *Sapotilla*. The Mava or Butter Tree of India, and the Sheo Tree of Mungo Park, also belong to this order. Examples, *Sersalisia*, *Argania*, *Sideroxylon*, *Bumelia*, *Chrysophyllum*, *Achras*, *Lucuma*, *Mimusops*, *Bassia*.

150. *Ebenaceæ*, Ventenat.—Flowers unisexual, rarely hermaphrodite; calyx three or six-parted, persistent; corolla downy outside, deciduous; limb three or six-parted, imbricate in æstivation; stamens definite, epipetalous or hypogynous, double the number of the segments of the corolla, sometimes four times that number, and sometimes equal in number to the segments of the corolla, and alternating with them; in hermaphrodite flowers the filaments are simple, in unisexual ones they are double, having both divisions bearing anthers, the inner division usually shorter than the outer; anthers fixed by their bases, lanceolate, two-celled, sometimes bearded; ovorium many-celled; cells one to two-seeded; ovula banging from the tops of the cells; style divided, rarely simple; stigmas bifid or trifid; berry globose or oval, generally few-seeded by abortion; albumen cartilaginous; embryo slender; radicle pointing to the umbilicus. Composed of middle-sized, nonlactescent trees and shrubs, with heavy wood, as the Ebony; leaves alternate, without stipulas, quite entire, coriaceous; peduncles axillary, solitary, those bearing the male flowers divided, and those bearing the female simple and one-flowered, all bracteate. The double stamens, unisexual flowers, and pendulous ovola distinguish this order. The fruit of the trees are edible, as the Date-Plum, Kaki, and Mabola. Examples, *Diospyros*, *Royena*, *Cargillia*.

151. *Oleinæ*, Hoffmannsegg.—Flowers generally hermaphrodite, seldom unisexual; calyx persistent, corolla four-cleft, seldom of four petals, or wanting, with a valvata æstivation; stamens two; anthers two-celled; ovarium two-celled; cells biovulate; ovula pendulous, side by side; style simple or wanting; stigma bifid or undivided; fruit drupaceous, baccate or capsular, often one-seeded by abortion; albumen dense; embryo straight; radicle superior. Composed of trees and shrubs with opposite, usually simple, rarely pinnate leaves, and racemose or panicled, terminal or axillary flowers; pedicels opposite, unibracteate. The bark of the Ash is bitter, and is celebrated as a febrifuge. Manna is an exudation from the bark of several species of *Ornus* and *Fraxinus*. The Olive is also of this family, which is divided into four tribes. Tribe 1. *Oleæ*. Corolla campanulate or urceolate, four-cleft; fruit drupaceous. Examples, *Ligustrum*, *Phillyrea*, *Olea*, *Chionanthus*. Tribe 2. *Syringeæ*. Corolla funnel-shaped or campanulate, four to five-parted; fruit capsular, two-celled. Examples, *Syringa*, *Fontanesia*. Tribe 3. *Notelæiæ*. Corolla of four petals; fruit drupaceous. Examples, *Notelæa*, *Linociera*. Tribe 4. *Fraxineæ*. Flowers polygamous; corolla of four petals, four-parted or absent; fruit two-celled, compressed, usually one-seeded, winged at top, samaroid. Examples, *Fraxinus*, *Ornus*.



152. *Ilicineæ*, Brongniart.—Sepals four to six, with an imbricate æstivation; corolla four to five-parted, with an imbricate æstivation; stamens four to five, epipetalous; anthers two-celled, introrse; ovarium superior, fleshy, two to six-celled; ovula solitary, hanging from a cup-shaped funicle; stigma almost sessile, lobed; fruit fleshy, indehiscent, containing from two to six one-seeded nuts; albumen fleshy; embryo small, lying next the hilum; radicle superior. Composed of trees and shrubs with coriaceous, opposite leaves. The leaves of *Ilex Parado* and *Ilex Paraguaensis* are used as tea. The bark and berries of some are tonic, astringent, and antiseptic. Examples, *Ilex*, the Holly, and *Prinos*.

153. *Jasmineaceæ*, R. Brown.—Calyx tubular, divided, or toothed, persistent; corolla salver-shaped; limb five-cleft, with an imbricate and twisted æstivation; stamens two, epipetalous; ovarium two-celled, cells one-seeded; ovula erect; style one, crowned by a two-lobed stigma; fruit a didymous berry, or a bipartite capsule; albumen sparing or wanting; embryo straight; radicle inferior. Composed of usually climbing shrubs with opposite, simple, but usually compound leaves, and having the flowers disposed in corymbs. This order differs sufficiently from *Oleinæ*, to which it is nearly allied, by the erect ovula, structure of seeds, and æstivation of the corolla. Fragrance is the principal property of this order. Examples, *Jasminum*, and *Nyctanthes*.

154. *Strychnaceæ*.—Calyx four to five-parted; corolla funnel-shaped; tube cylindrical; limb four to five-parted, with an imbricate æstivation; stamens four to five, short; anthers subsagittate or oblong, two-celled; ovarium superior, two-celled; ovula numerous, attached to a receptacle down the middle of the partition; berries large, two-celled, but in a more advanced state only one-celled; seeds few or many, flattened, peltate, broad, nestling in the pulp, albuminous; embryo straight; radicle pointing to the hilum; cotyledons often three-nerved. Composed of erect or rambling shrubs, either with or without tendrils, and opposite, three-nerved, or triple-nerved leaves; flowers small, disposed in axillary or terminal pedunculate corymbs. The well-known *Nux-Vomica* belongs to this order. Examples, *Strychnos*, *Lasiostoma*.

155. *Potaliaceæ*, Martius.—Calyx four to five-parted; corolla tubular; limb nearly equal, five to twelve-cleft, with a twisted and imbricate æstivation; stamens five, ten, or twelve, monadelphous or free; style continuous; stigma simple; berry two or four-celled; seeds numerous, peltate, fixed to the placentas, which are central; albumen cartilaginous. Composed of glabrous, lactescent trees or shrubs, with opposite, quite entire leaves, which are joined by interpetiolar sheathing stipulas, and

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bracteate flowers, which are disposed in terminal, panicled corymbs. Distinguished from *Apocyneæ*, to which it is most nearly allied, by the unequal parts of the flower, by the double testa to the seed, and by the petioles being joined by interpetiolar stipulas. Examples, *Potalia, Anthocleista, Fagræa.*

156. *Apocyneæ*, Jussieu.—Calyx five-cleft, permanent; corolla five-lobed, deciduous, with an imbricate æstivation; stamens five, epipetalous; anthers two-celled; ovarium solitary or twin, usually many-seeded, therefore the styles are either one or two; stigmas, when two, applied to each other; fruit follicular, drupaceous or baccate, solitary or twin, one or many-seeded; seeds generally albuminous; embryo foliaceous. Composed of trees and shrubs full of milky acrid juice; leaves opposite, seldom verticillate or scattered, quite entire, usually furnished with interpetiolar ciliæ or glands; inflorescence somewhat corymbose or racemose. Readily distinguished from *Asclepiadeæ*, to which it is nearest allied, by the structure of the anthers and stigmas; and from *Strychnaceæ* in the seeds not being peltate. The properties of *Apocyneæ* are acrid, stimulating and astringent, purgative and dangerous. *Tanghinia* is the famous ordeal of Madagascar. The twisted direction of the corolla of all have been likened to St. Catherine's Wheel. The order is separated into ten tribes. Tribe 1. *Echitieæ.* Fruit of two follicles, or a two-celled capsule; seeds furnished with a tuft of hairs at the umbilical end. Examples, *Echites, Beaumontia, Thenardia, Apocynum, Strophanthus.* Tribe 2. *Wrightieæ.* Fruit of two follicles; seeds furnished with a tuft of hairs at that end contrary to the umbilicus. Example, *Wrightia.* Tribe 3. *Alstonieæ.* Fruit of two follicles; seeds peltate, ciliated, the cilia lengthened at each end. Example, *Alstonia.* Tribe 4. *Gelsemieæ.* Fruit of two combined follicles, two-valved, two-celled, the inflexed edges of the valves constituting the dissepiments, and bearing the seeds on their margins. Example, *Gelsemium.* Tribe 5. *Tabernemontaneæ.* Fruit of two follicles, rarely solitary; seeds nestling in the pulp; albumen present. Examples, *Tabernemontana, Cameraria, Plumiera, Vinca.* Tribe 6. *Alyxieæ.* Fruit subdrupaceous; albumen ruminated as in *Anonaceæ.* Examples, *Alyxia, Cerbera, Ophioxylon, Rauwolfia.* Tribe 7. *Kopsieæ.* Fruit subdrupaceous; albumen wanting. Example, *Kopsia.* Tribe 8. *Melodineæ.* Fruit baccate, solitary; seeds compressed, imbedded in the pulp, usually albuminous. Examples, *Melodinus, Willughbeia.* Tribe 9. *Allamandieæ.* Fruit capsular, prickly or smooth; seeds peltate, fixed to the central placenta; albumen none. Example, *Allamanda.* Tribe 10. *Carandieæ.* Fruit baccate; seeds peltate, winged; albumen copious. Example, *Carissa.*

157. *Asclepiadeæ*, R. Brown.—Calyx five-cleft, persistent; corolla five-lobed, with an imbricate, rarely valvate, æstivation; stamens five, inserted in the bottom of the corolla, usually connected; anthers two-celled, and sometimes almost four-celled; pollen masses equal in number to the cells of the anthers, fixed to the five processes of the stigma; ovaria twin; styles two, close together, crowned to one stigma, which is common to both, the angles of which bear corpuscles; fruit of two follicles; seeds numerous, imbricated, pendulous, furnished with a tuft of hairs at the umbilicus; albumen thin; embryo straight; cotyledons foliaceous; radicle superior. Composed of shrubs, rarely herbs, for the most part lactescent and climbing; leaves entire, usually opposite, rarely alternate or verticillate, usually furnished with interpetiolar cilia in place of stipulas; flowers disposed in umbels, fascicles, or racemes, always interpetiolar. The pollen being combined into a definite number of waxy masses separates this order from all other dicotyledonous ones. In some the odour of the flowers is very pleasant, as in *Pergularia*, and in others very fetid, as in *Stapelia*. The roots of many are emetic. The young shoots of some are used as food, although the greater mass are poisonous. The order is divided into four separate tribes. Tribe 1. *Orthophuramiæ.* Pollen masses ten, erect, or connivent, fixed by pairs to the corpuscles of the stigma, that is five two-celled anthers separable into two parts by a longitudinal furrow. This tribe is separated into two subtribes. Subtribe 1. *Stapelieæ.* Anthers not terminated by membranes. Examples, *Ceropegia, Stapelia, Caralluma, Brachystelma.* Subtribe 2. *Hoyaceæ.* Anthers terminated by membranes. Examples, *Hoya, Pergularia.* Tribe 2. *Gonolobeæ.* Pollen masses ten, transverse, attached by pairs to the corpuscles of the stigma, that is five two-celled anthers separable into two parts by a transverse furrow; stamineous corona simple, lobed. Example, *Gonolobus.* Tribe 3. *Asclepieæ.* Pollen masses ten, two of which appertain to each anther, fixed to the corpuscles of the stigma by their apices or above the middle of the side, pendulous, that is five two-celled anthers separable into two parts by a longitudinal furrow; anthers terminated by membranes. Examples, *Asclepias, Gomphocarpus, Calotropis, Cynanchum.* Tribe 4. *Secamoneæ.* Pollen masses twenty, erect, that is four to each anther, which are fixed to the five corpuscles of the stigma; filaments connate. Example, *Secamone.* Tribe 5. *Periploceæ.* Pollen masses from five to twenty, granular, each granule composed of four spherules, applied singly or by fours to each corpuscle of the stigma; filaments distinct. Examples, *Cryptostegia, Periploca, Hemidesmis.*

158. *Menyanthaceæ*, G. Don.—Calyx five-parted, persistent; corolla subrotate; disks of segments bearded or squammulose at their bases, or bearded lengthwise, with an inflexed æstivation; stamens five; style one; stigma two lobed; lobes toothed; hypogynous glands five, alternating with the stamens; capsule one-celled, many-seeded, two-valved, except in the aquatic genera, which is valveless; the seeds attached to parietal placentas on the edges of the valves. Composed of floating aquatic or marsh herbs; leaves simple or trifoliate, toothed, usually alternate, rarely opposite; flowers subumbellate, axillary, sometimes on the petioles, or panicled and terminal; segments of corolla fringed or entire. The order agrees with *Gentianeæ* in many particulars, but differs in habit and alternate leaves; the properties are also like it, tonic, stomachic, and febrifugal. Examples, *Menyanthes* and *Villarsia.*

159. *Spigeliaceæ*, Martius.—Calyx five-parted; corolla five-parted, with a valvate æstivation; stamens five, epipetalous; pollen trigonal; style articulated; stigma simple; capsule of two two-valved cocci, with a free central placenta each; seeds small; testa simple; albumen fleshy; embryo straight. Composed of very ornamental herbs or undershrubs, with opposite, quite entire, stipulate, or substipulate leaves, and having the flowers disposed in secund bracteate spikes. The style being articulated, and the placenta central, separates this family from *Gentianeæ*, to which it is nearest allied. The annual species are vermifuge, and the perennial species

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anthelmintic, as the Indian Pink of the shops. Examples, *Spigelia*, *Mitrasacme*, *Mitreola*.

160. *Gentianeæ*, Jussieu.—Calyx four to five-cleft, persistent; corolla marcescent or deciduous, with a four to five-cleft limb, with an imbricate æstivation; stamens four to five, epipetalous; ovarium one to two-celled, many-seeded; styles one or two, when the latter number they are combined; stigmas one to two; capsule usually dry, rarely baccate, one to two-celled, many-seeded, usually two-valved; margins of the valves bent in and bearing the seeds in those with one-celled capsules, but in those with two-celled capsules the placentas are central; albumen fleshy; embryo straight; radicle tending to the umbilicus. Composed of herbs, rarely shrubs, with opposite, entire, exstipulate leaves, and terminal or axillary flowers. This order is more readily distinguished by habit than by character; it differs from *Polemoniaceæ* in the dehiscence of the capsule and placentation of the seeds; and from *Spigeliaceæ* in the style not being jointed. The properties are eminently tonic, stomachic, and febrifugal, their bitterness second only to Quassia and Peruvian Bark. The order is divided into three tribes. Tribe 1. *Gentianieæ*. Capsule one to two-celled; margins of valves placentiferous; seeds usually disposed in a double row. This is divided into four subtribes, *Gentianeæ veræ*, *Contoubeæ*, *Chironieæ*, and *Lisiantheæ*; in the two first the anthers remain unchanged, and in the two latter the anthers become changed in the old state. Examples, *Swertia*, *Gentiana*, *Chlora*, *Contoubea*, *Chironia*, *Erythræa*, *Lisianthus*. Tribe 2. *Exacieæ*. Capsule two-celled; central placentas at length free. Examples, *Exacum*, *Microcale*. Tribe 3. *Desfontainieæ*. Berry one-celled, many-seeded, with four to five parietal placentas. Evergreen shrubs, with spiny-toothed leaves, and terminal, solitary, pedunculate flowers. Example, *Desfontainia*.

161. *Stilbineæ*, Kunth.—Calyx tubularly campanulate; limb five-cleft; segments equal, or the two lower ones are more deeply divided; rarely of five sepals, persistent; corolla monopetalous, hypogynous; tube widened at the throat; limb five-parted, spreading, subbilabiate, rarely four-parted, and nearly regular, with a valvate æstivation; stamens equal in number to the segments of the corolla, and inserted at the top of the tube, protruding, nearly equal, the fifth always barren; anthers fixed by their backs; ovarium superior, sessile, two-celled, each cell containing one erect ovulum, and sometimes one of the cells is smaller and empty; style filiform; stigma simple, emarginate; disk none; fruit dry, one-seeded, indehiscent, covered by the persistent calyx. Composed of small shrubs, with the habit of *Phylica* or *Abies*, natives of the Cape of Good Hope; leaves verticillate, crowded, narrow, entire, coriaceous, rigid, exstipulate, articulated at their bases; flowers disposed in dense spikes at the tops of the branches, sessile, tribracteate at the base, sometimes polygamous. In habit and some other characters this order seems to be nearly allied to *Aragoaceæ*. Example, *Stilbe*.

162. *Aragoaceæ*, D. Don.—Calyx five-parted; corolla salver-shaped; limb four-lobed, with a convolutely imbricated æstivation; stamens four, inserted in the recesses between the lobes of the corolla; anthers cordate, with confluent cells; style filiform; stigma capitate; capsule two-celled, two-valved; valves bifid; dissepiment parallel with the valves; seeds compressed, with a membranous border, four or five in each cell; albumen fleshy; embryo erect; cotyledons fleshy, plano-convex; radicle short, blunt. Composed of much branched shrubs, natives of the mountains about Santa Fe de Bogota; branches opposite; leaves small, coriaceous, imbricated in eight rows; flowers small, axillary, solitary, nearly sessile, white. The bilocular ovarium, confluent cells of anthers, and undivided stigma and peculiar habit, readily distinguish this order from *Polemoneaceæ*, to which it is most nearly allied.



163. *Polemoneaceæ*.—Calyx five-cleft or five-toothed, persistent; corolla rotate, salver-shaped or funnel-shaped; limb five-lobed, imbricate or twisted in æstivation; stamens five, epipetalous; anthers incumbent, two-celled, sagittate; ovarium three-celled; ovula numerous, rarely definite; style long; stigma of three linear blunt lobes; capsule three-celled, three-valved; valves septiferous in the middle; placenta central, trigonal; seeds angular, or compressed and girded by a membrane; testa simple, mucilaginous; albumen fleshy; embryo straight; radicle inferior; cotyledons foliaceous. Composed of beautiful herbs and undershrubs; leaves usually alternate, rarely opposite, undivided, pinnatifid, or pinnate; flowers numerous and terminal, or axillary and usually solitary, bracteate in most of the species. The five-lobed regular corolla, the three-lobed stigma, the three-celled, three-valved capsule, the septiferous valves, the trigonal, central placenta, the fleshy albumen, and straight embryo, and mucilaginous seeds distinguish this order from all its allies. Examples, *Polemonium*, *Diapensia*, *Phlox*, *Leptosiphon*, *Gilia*, *Cantua*.

164. *Hydroleaceæ*, D. Don.—Calyx persistent, five-cleft; segments generally spatulately dilated at tops; corolla usually campanulate, five-lobed; stamens five, epipetalous; styles two; stigmas thick or capitate; ovarium two-celled, many-seeded; capsule two-celled, two-valved; valves septiferous in the middle; placentas two in each cell, fixed to the middle of the septum, sometimes spongy and combined, sometimes laminæform and separated; seeds numerous, sessile; albumen fleshy; embryo straight. Composed of herbs or undershrubs, with alternate, simple, entire, or toothed, usually petiolate leaves; flowers corymbose or spicate, also disposed in the manner of *Heliotropium*. The habit and character of this order comes nearest to *Scrophularineæ* and *Solaneæ*, but differs from them in the regular flowers. The genus *Codon* differs from the other genera of the order in the calyx being ten to twelve-parted, the corolla ten to twelve-lobed, and the stamens being ten or twelve. Examples, *Hydrolea*, *Wigandia*.

165. *Convolvulaceæ*, Jussieu.—Calyx usually of five sepals, rarely five-toothed, persistent; sepals equal or unequal, disposed in one, two, or three series; corolla tubular, campanulate, or funnel-shaped; limb of five plaits or five lobes, with a twisted æstivation; stamens five, epipetalous, unequal; anthers long, generally sagittate, adnate at their bases, often twisted afterwards; hypogynous disk annular, surrounding the ovarium in most of the species; ovarium generally simple, two to four-celled, rarely almost one-celled, and sometimes double or quadruple, and in each cell there are one or two erect ovula; style entire or cleft, rarely two; stigmas acute, flattened or globose; capsule usually dehiscing valvately, rarely transversely; seeds usually rounded on one side and flattened on the other, inserted by their bases, glabrous or villous; albumen mucilaginous; cotyledons foliaceous, corrugated; radicle incurved,

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inferior. Composed of herbs or shrubs, rarely trees, erect, creeping, but generally twining; leaves alternate, simple, entire or lobed, sessile or petiolate; peduncles axillary or terminal, one or many-flowered; roots simple or tuberous. Scammony, Jalap, and some other drugs are the produce of this order. The Sweet Potato and the roots of some other species are wholesome articles of food. The flowers only expand under the influence of sunshine. This order is divided into four different tribes. Tribe 1. *Argyreiceæ*. Ovarium simple; pericarp baccate, indehiscent. Examples, *Rivea*, *Argyreia*. Tribe 2. *Convolvuleæ*. Ovarium simple; pericarp capsular, dehiscent. Examples, *Convolvulus*, *Ipomœa*, *Calystegia*, *Porana*, *Evolvulus*, *Cressa*. Tribe 3. *Dichondreæ*. Carpels two or four, distinct. Examples, *Dichondra*, *Falkia*. Tribe 4. *Cuscuteæ*. Embryo without cotyledons. Example, *Cuscuta*.

166. *Retziaceæ*, Bartling.—Calyx bracteate, imbricate, five-parted; corolla cylindrical; stamens epipetalous; anthers two-celled, sobcordate; stigma bifid or twin; capsule two-celled, having the dissepiment placentiferous on both sides, many-seeded. Composed of branched, erect shrubs; leaves alternate or four in a whorl; flowers sessile, lateral at the tops of the branches. The many-seeded cells of the capsule and the placentiferous dissepiment readily distinguish this order from all its allies. Examples, *Retzia*, *Lonchostoma*.

167. *Boragineæ*, Jussieu.—Calyx five-parted, rarely four-parted, persistent; corolla five-cleft, rarely four-cleft, with an imbricate æstivation; stamens five, rarely four; ovarium four-parted, four-seeded, or simple, two or four-celled; achenia four, distinct or combined; albumen none; embryo inverted. Composed of herbs or shrubs harsh from asperities, with alternate, exstipulate leaves, and having the flowers generally disposed in secund spikes or racemes, seldom panicled or corymbose, or axillary and solitary. The properties are generally mucilaginous and emollient. A red colour is given out by some of the species, which is used in dyeing. This order is divided into four distinct tribes. Tribe 1. *Borageæ*. Achenia four, distinct, imperforated at their bases. Examples, *Borago*, *Symphytum*, *Onosma*, *Pulmonaria*, *Cerinthe*, *Lithospermum*, *Echium*, *Lycopsis*. Tribe 2. *Buglosseæ*. Achenia four, distinct, perforated at their bases. Examples, *Anchusa*, *Myosotis*. Tribe 3. *Cynoglosseæ*. Achenia four, distinct, fixed to the central column. Examples, *Cynoglossum*, *Asperugo*, *Echinospermum*, *Rindera*. Tribe 4. *Heliotropeæ*. Achenia four, two-celled, combined into a single fruit, without any manifest receptacle. Examples, *Heliotropium*, *Tournefortia*.

168. *Cordiaceæ*, G. Don.—Calyx five-cleft, or four to five-toothed; corollo funnel-shaped; limb five to ten-lobed; stamens five to ten, epipetalous; style semibifid or dichotomous; stigmas blunt; drupe containing two two-celled, two-seeded nuts, or four one-celled, one-seeded nuts, or a four-celled putamen, which is often fewer-celled by abortion, partly or altogether covered by the calyx; cotyledons plicate. Composed of shrubs and trees harsh from asperities, with alternate, entire, or serrated leaves, and terminal, panicled, corymbose or spicate, usually bractless, inflorescence. The habit, plicate cotyledons, divided style, readily distinguishes this order from *Boragineæ*. The fruit is emollient and mucilaginous. Divided into three tribes. Tribe 1. *Cordieæ*. Style dichotomous; stigmas four; fruit containing a four-celled putamen. Examples, *Cordia*, *Patagonula*. Tribe 2. *Ehretiaceæ*. Style semibifid; stigmas two; fruit containing four one-celled, one-seeded nuts, or two two celled, two-seeded nuts. Examples, *Ehretia*, *Cortesia*, *Beurreria*. Tribe 3. *Erimataleæ*. Style hardly any; stigma large, discoid, five-grooved; drupe containing a single, one-celled, one-seeded nut. Example, *Erysibe*.



169. *Hydrophylleæ*, R. Brown.—Calyx five-cleft, persistent, the recesses between the segments usually furnished with reflexed appendages; corolla rotately campanulate, rarely somewhat funnel-shaped; stamens five, perigynous; anthers versatile, two-celled; ovarium one-celled; style bifid; stigmas two; placentas free at the back, or adnate to the parietes, bearing two or many ovula on their inner surface; capsule two-valved, often one-celled in consequence of the large placentas filling the capsule, but when the dissepiment is hardly complete the capsule is half two-celled; albumen cartilaginous; embryo conical; radicle pointing to the hilum. Composed of elegant herbs, harsh like those of *Boragineæ*, with usually lobed, alternate leaves, or the lower leaves are opposite. The flowers are disposed in one-sided, somewhat dichotomous spikes or racemes, which are scorpoid at first; corollas blue or pink, elegant. The capsular fruit, cartilaginous albumen, placentation of the seeds, and the compound or deeply-lobed leaves, separate this order from its nearest ally, *Boragineæ*. Examples, *Hydrophyllum*, *Nemophila*, *Eutoca*, *Phacelia*, and *Ellisia*.

170. *Solanaceæ*, Jussieu.—Calyx five-cleft, rarely four-cleft, persistent; corolla five-cleft, rarely four-cleft, regular, or a little unequal, with a plicate or imbricate æstivation; stamens five, rarely four, epipetalous; ovarium one, two, three, or four-celled, many-seeded; style one; stigma obtuse, rarely lobed; fruit two to four-celled, either a capsule with parallel or duplicate dissepiments, or a berry having the placentas adnate to the dissepiments; albumen fleshy; embryo having the radicle tending to the umbilicus. Composed of herbs or shrubs of a peculiar nauseous scent; leaves alternate, undivided or lobed, the floral ones placed nigh together, often twin; inflorescence variable, but generally extra-axillary; pedicels without bracteas. The usually regular flowers, arched or spiral embryo, plicate æstivation of corolla, and equal stamens, distinguish this order from *Scrophularineæ*, to which it comes nearest. Most of the plants of this family are dangerous and poisonous, as the Deadly Nightshade, Henbane, Tobacco, &c.; and others are wholesome food, as the Potato, Tomatoe, Winter Cherry. The larger portion of the species are extremely beautiful when in blossom. The order is divided into several tribes. Tribe 1. *Solaneæ*. Corolla with a plicate æstivation; embryo curved; fruit baccate. Examples, *Solanum*, *Physalis*, *Atropa*, *Capsicum*, *Lycium*. Tribe 2. *Nicotianeæ*. Corolla with a plicate æstivation; capsule two-celled, two-valved; valves bifid; embryo much curved. Examples, *Nicotiana*, *Petunia*, *Nierembergia*, *Salpiglossis*, *Schizanthus*, *Hyocymus*. Tribe 3. *Datureæ*. Corolla repandly five-toothed, with a plicate æstivation; capsule coriaceous, two-celled, two-valved; valves bifid; placentas septiform, free; seeds reniform. Examples, *Datura*, *Solandra*, *Brugmansia*, *Ulloa*. Tribe 4. *Franciseeæ*. Corolla unequal, with a plicate æstivation; stamens four, didynamous; capsule two-celled, two-valved; valves bifid; placentas inserted into the dissepiment;

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embryo terete, straight. Examples, *Brunfelsia*, *Franciscea*, *Browallia*. Tribe 5. *Anthocerceæ*. Corolla regular, not plicate; stamens four, didynamous, with the rudiment of a fifth; embryo arched; fruit capsular or baccate. Examples, *Anthocercis*, *Duboisia*. Tribe 6. *Nolaneæ*. Corolla regular, with a plicate æstivation; drupe solitary, or five together, containing each a two or four-celled bony nut; embryo spiral. Examples, *Nolana*, *Triguera*, *Grabowskia*. Tribe 11. *Cestrineæ*. Corolla regular, plicate, valvate, imbricate, or induplicate in æstivation; fruit capsular or baccate; placentas free or adnate to the dissepiment; embryo nearly straight. Examples, *Cestrum*, *Dunalia*, *Vestia*, *Sessea*, *Fabiana*.

171. *Verbascineæ*, Nees ab Esenbeck. — Corolla rotate, five-cleft, unequal; stamens five, of different forms, the upper one often sterile or wanting; anther one-celled, adnate to a hatchet-shaped connective; capsule composed of two joined carpels; placentas marginal, combined into a central column, which is free from the margins, and constitute the axis of the dissepiment; seeds many, reniform, albumiuous; embryo a little arched, central. Composed of strong, robust herbs, of a mucilaginous substance, with alternate, usually decurrent leaves; flowers disposed in elongated racemes or spikes, propped by the decreasing leaves; corollas white, yellow, rarely purple; filaments usually bearded. The one-celled anthers, which are often unequal and of different forms in the same flower, separate this order both from *Solanaceæ* and *Scrophularineæ*. Examples, *Verbascum*, *Celsia*, *Ramondia*.

172. *Scrophularineæ*, R. Brown.—Calyx four to five-parted, persistent; corolla deciduous, irregular, bilabiate, personate or ringent, with an imbricate æstivation; stamens four, usually didynamous, but also often two, and sometimes with the rudiment of a fifth; ovarium two-celled; style one; stigma two-lobed or undivided; fruit usually capsular, rarely baccate, two-celled, two or four-valved, many-seeded; seeds small; albumen copious; embryo erect; radicle pointing to the umbilicus. Composed of herbs and shrubs very various in habit and inflorescence; leaves generally opposite. The greater part of Linnæus's *Didynamia Angiospermia* belongs to this order, which contains plants from all parts of the world, some of which are very ornamental; most of them have a bitterish, acrid taste. *Digitalis* is dangerous, but is used in the cure of many obstinate complaints, such as Scrophula, Dropsy, and Asthma. The order is divided into the following prominent tribes, viz.: Tribe 1. *Digitaleæ*. Stamens didynamous; cells of anthers confluent at the apex; flowers racemose. Examples, *Digitalis*, *Scrophularia*, *Alonsoa*. Tribe 2. *Antirrhineæ*. Stamens didynamous; cells of anthers distinct at top. Examples, *Anterrhinum*, *Linaria*, *Maurandia*, *Lophospermum*, *Nemesia*. Tribe 3. *Gratioleæ*. Stamens didynamous, or only two; cells of anthers diverging. Examples, *Gratiola*, *Herpestis*, *Mimulus*, *Collinsia*, *Leucocarpus*. Tribe 4. *Gerardieæ*. Corolla campannlate; limb rather bilabiate; stamens didynamous; cells of anthers diverging, usually spurred at the base. Examples, *Gerardia*, *Seymeria*, *Escobedia*, *Physocalyx*. Tribe 5. *Veroniceæ*. Corolla rotate or tubular, irregular; stamens usually two, seldom four; cells of anthers parallel and distinct; stigma capitate. Examples, *Veronica*, *Pæderota*. Tribe 6. *Buckneræ*. Corolla salver-shaped, nearly equal; stamens didynamous; anthers usually one-lobed from the cells being contiguous; stigma undivided. Examples, *Bucknera*, *Erinus*, *Manulea*. Tribe 7. *Buddleieæ*. Corolla tubular, with an equal limb; stamens four, equal; cells of anthers parallel, distinct; stigma clavate, two-lobed. Example, *Buddlea*. Tribe 8. *Calceolarieæ*. Corolla bilabiate; the upper lip very large and saccate; stamens two or four; cells of anthers diverging at base, but confluent at apex; stigma capitate. Examples, *Calceolaria*, *Angellonia*. Tribe 9. *Euphrasieæ*. Corolla bilabiate; stamens didynamous; cells of anthers parallel, usually spurred at the base; stigmo undivided. Examples, *Euphrasia*, *Bartsia*, *Castilleja*. Tribe 10. *Teedieæ*. Corolla nearly equal; fruit baccate. Examples, *Teedia*, *Freylinea*. Tribe 11. *Hallerieæ*. Corolla curved, tubular; limb unequal; stamens didynamous; fruit baccate. Example, *Halleria*.



173. *Rhinanthaceæ*, De Candolle.—Calyx tubular, four to five-cleft, persistent; corolla deciduous, irregular, bilabiate; upper lip usually galeate; æstivation imbricate; stamens four, didynamous; anthers spurred at their bases; ovarium two-celled; stigma undivided; capsule two-celled, two or four-valved, many-seeded; albumen fleshy; embryo inverted, terete; radicle contrary to the umbilicus. Composed of humble herbs or undershrubs, natives of all quarters of the globe in temperate places; leaves usually opposite or pinnatifid; flowers disposed in terminal, bracteate spikes or racemes. This is intimately allied to the preceding order, but is distinguished by the inverted embryo having the radicle directed to that extremity of the seed opposite the umbilicus. It is divided into two tribes. Tribe 1. *Rhinanthieæ*. Embryo minute at the apex of the albumen. Examples, *Rhinanthus*, *Elephas*, *Pedicularis*, *Melampyrum*. Tribe 2. *Cymbarieæ*. Embryo rather foliaceous, nearly the length of the albumen. Example, *Cymbaria*.

174. *Orobancheæ*, Jussieu.—Calyx persistent, divided; corolla tubular, irregular, bilabiate, with an imbricate æstivation; stamens four, didynamous; anthers usually spurred at their bases; ovarium one-celled; stigma two-lobed or undivided; capsule one-celled, two-valved, many-seeded; seeds inserted into narrow, parietal placentas, which rise from the margins of the valves; albumen cartilaginous; embryo inverted, minute, nearly globose, placed at the apex of the albumen, usually undivided; radicle superior, remote from the umbilicus. Composed usually of parasitical, leafless, rather fleshy, rust-coloured, scaly herbs; flowers terminal, solitary, or disposed in spikes or racemes. The persistent corolla, one-celled ovarium, centrifugal embryo, and peculiar habit, being destitute of leaves and the green colour common to other plants, distinguish it well from the preceding and following families. The order is divided into two tribes. Tribe 1. *Orobanchieæ*. Parasitical, leafless herbs. Examples, *Orobanche*, *Lathræa*. Tribe 2. *Obolarieæ*. Terrestrial, leafy plants. Examples, *Obolaria*, *Tozzia*.

175. *Cheloneæ*, D. Don.—Calyx five-parted, persistent; corolla tubular; limb five-lobed, bilabiate; stamens four, didynamous, with the rudiment of a fifth; anthers two-celled, spurless; cells confluent at apex; stigma undivided; capsule two-celled, many-seeded; seeds erect, angular, or compressed; albumen fleshy; embryo erect, foliaceous. Composed of elegant North American herbs or subshrubs, with opposite leaves, and racemose or panicled inflorescence. The many-parted calyx, undivided stigma, and erect, albuminous seeds of this



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order, separates it from the two following, *Bignoniaceæ* and *Pedalineæ*, to which it is most nearly allied. The presence of a rudimentary stamen readily distinguishes it from *Scrophularineæ*. Examples, *Chelone, Pentstemon*.

176. *Bignoniaceæ*, R. Brown.—Calyx divided or entire, and sometimes spathaceous; corolla tubular, limb generally irregular, four to five-lobed; stamens five, but either one or three of them are sterile, therefore the flowers are didynamous or diandrous; anthers two-celled; cells equal in insertion, usually divaricate; ovarium girded by a glandular disk, two-celled, or falsely four-celled, many-seeded; stigma bilamellate; capsule two-valved, two-celled, or falsely four-celled; dissepiment parallel or contrary, bearing the seeds at the commissures with the valves; seeds compressed, transversely winged; albumen none; embryo straight, foliaceous; radicle centrifugal. Composed of superb trees and shrubs, the latter usually climbing. Leaves opposite, seldom alternate, generally compound, seldom simple, always without stipulas; inflorescence terminal and axillary, somewhat panicled; corollas trumpet-shaped, showy. This order is readily distinguished from its allies, by the structure of the fruit and placentation of the seeds. It is divided into three tribes. Tribe 1. *Bignonieæ*. Capsule two-celled, or falsely four-celled; seeds transverse. Examples, *Bignonia, Tecoma, Jacaranda, Spathodea, Calosanthes, Catalpa*. Tribe 2. *Tourrettieæ*. Capsule one-celled; placentas fleshy; seeds horizontal. Examples, *Tourrettia, Calampelis*. Tribe 3. *Crescentieæ*. Fruit baccate, melon-shaped, with a solid rind; seeds nestling in the pulp. Examples, *Crescentia*, or Calabash tree, and *Tanæcium*.

177. *Pedalineæ*, R. Brown.—Calyx five-parted, nearly equal; corolla tubular, with a ventricose throat and bilabiate limb; stamens four, didynamous, with the rudiment of a fifth; ovarium girded by a glandular disk of many spurious one to two-seeded cells; stigma undivided; fruit drupaceous, dry, usually muricated, of several cells, which are formed by the splitting of two placentas, and the divergence of their lobes; seeds pendulous, erect, or horizontal; albumen none; embryo straight. Composed of erect, branched herbs, with opposite leaves, and axillary, solitary, pedunculate, bibracteate flowers. The definite wingless seeds and woody, parietal, lobed placentas, separate this order from its nearest ally, *Bignoniaceæ*. The seeds of *Sesamum* yield abundance of fixed oil by expression, as tasteless as olive oil, and the leaves are emollient. The fresh leaves of *Pedalium murex*, when agitated in water, renders the water mucilaginous, and in that state it is prescribed by Indian doctors in dysuria. Examples, *Pedalium, Craniolaria, Martynia, Sesamum*.

178. *Cobæaceæ*, D. Don.—Calyx foliaceous, five-cleft, equal; corolla campanulate, regular, five-lobed, with an imbricate æstivation; stamens five, unequal; anthers two-celled, compressed; ovarium three-celled, surrounded by a fleshy annular disk; ovula several, ascending; stigma trifid; capsule three-celled, with a septicidal dehiscence; placenta large, three-cornered, its angles touching the lines of the dehiscence of the pericarp; seeds compressed, winged, imbricated in a double row; integument mucilaginous; albumen fleshy; embryo straight; cotyledons foliaceous; radicle inferior. Composed of climbing shrubs, natives of Mexico, with alternate, abruptly pinnate leaves, having the common petioles lengthened out into tendrils; and large, axillary, solitary, pedunculate flowers. The pentandrous, regular flowers and presence of albumen distinguish this order from the two preceding. It comes, however, nearer to *Polemoniaceæ* in character, but is readily distinguished by habit and the winged seeds. Example, *Cobæa*.



179. *Gesneriaceæ*, Richard.—Calyx five-cleft; corolla oblique, tubular; limb five-cleft, bilabiate; stamens four, didynamous, generally with the rudiment of a fifth, all fertile, or two of them are sterile; anthers distinct, or cohering by pairs, or altogether; ovarium one-celled; placentas two, parietal and bilamellate; fruit capsular or baccate, silique-formed or round; seeds numerous, hanging by long funicles, or erect; albumen copious or wanting; embryo straight, slender. Composed of herbs or subshrubs, which are usually tuberescent at their bases; leaves opposite or verticillate, rarely alternate, thickish, entire; inflorescence cymose, rarely racemose, axillary; corollas elegant, of various hues; the leaves of all are emollient. The order is divided into two tribes, and these tribes again are further divided into several subshrubs. Tribe 1. *Gesnerieæ*. Calyx usually adhering to the ovarium at the base, the ovarium is therefore half inferior; seeds albuminous. Examples, *Trevirania, Gesneria, Gloxinia, Rytidocarpum, Columnea*. Tribe 2. *Cyrtandraceæ*. Ovarium wholly superior; seeds without albumen. Examples, *Æschynanthus, Didymocarpus, Streptocarpus, Cyrtandra, Fieldia, Platystemma, Ourisia, Aikinia*.

180. *Labiatæ*, Jussieu.—Calyx persistent, tubular, five-cleft, or five to ten-toothed, regular or bilabiate, having the lips entire or divided; corolla tubular; limb bilabiate; the upper lip undivided or bifid, and the lower lip trifid, lying over each other in æstivation; stamens four, didynamous, two of which are often sterile; filaments inserted under the sinuses of the lower lip; anthers two-lobed; lobes usually divaricate, but sometimes dimidiate, and therefore somewhat one-celled; ovaria four, one-seeded, seated on a glandular disk, and connected with the base of the style; ovula erect; stigma bifid; achenia four, or fewer from abortion; albumen wanting or very sparing; embryo erect; cotyledons flat. Composed of herbs, rarely of shrubs, with tetragonal branches and stems; leaves opposite, without stipulas, simple or lobed; flowers opposite, verticillate, capitate or spicate, racemose or solitary, axillary or terminal, bracteate or naked. The opposite leaves and free, four-lobed ovarium, bilabiate corolla, and didynamous stamens readily distinguish it from *Borragineæ*, and the four-lobed, free ovarium separates it from *Verbenaceæ, Scrophularineæ, Acanthaceæ*, &c. The plants are to be found in more or less abundance throughout the surface of the globe. They are used as stomachics and febrifuges, as Savory, Thyme, Basil, and Marjoram for seasoning food, Sage and Balm for tea, Lavender and Rosemary for perfume. The essential oil of all contains camphor in more or less abundance. The *Didynamia Gymnospermia* of Linnæus contain all the genera with four stamens. The order has been divided into eleven different tribes by Mr. Bentham, the diagnoses of which do not appear to be very clear from the difficulty of finding characters in so natural a family. Tribe 1. *Ocymoideæ*. Corolla subbilabiate; stamens declinate; old anthers usually saucer-shaped. Examples, *Ocymum, Plectranthus, Anisochilus, Hyptis, Lavandula*. Tribe 2. *Menthoideæ*, Corolla subcampanulate or funnel-shaped; stamens distant. Examples, *Pogostemon, Colebrookia, Mentha*. Tribe 3. *Monardeæ*. Corolla bilabiate; upper stamens abortive, or when fertile bearing linear, connate anthers,

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the other anthers dimidiate. Examples, *Salvia, Rosmarinus, Monarda*, and *Ziziphora, Horminum*. Tribe 4. *Satureineæ*. Stamens straight, diverging, hardly ascending; anthers not dimidiate. Examples, *Hystropogon, Pychnanthemum, Origanum, Thymus, Satureia, Hyssopus, Collinsonia, Cunila*. Tribe 5. *Melissineæ*. Stamens ascending, superior ones shorter or abortive. Examples, *Melissa, Gardoquia, Thymbra*. Tribe 6. *Scutellarineæ*. Calyx bilabiate, upper lip truncate, entire, or tridentate; stamens ascending, superior ones shortest. Examples, *Prunella, Scutellaria*. Tribe 7. *Prostanthereæ*. Achenia coriaceous, reticulately wrinkled, style permanent. Examples, *Prostanthera, Westringia*. Tribe 8. *Nepeteæ*. Stamens four, lower ones the shortest, ascending or diverging. Examples, *Lophanthus, Nepeta, Dracocephalum*. Tribe 9. *Stachydeæ*. Stamens four, ascending, the superior ones the shortest. Examples, *Melittis, Lamium, Leonurus, Galiopsis, Stachys, Sederitis, Marrubium, Ballota, Leucas, Phlomis, Molucella*. Tribe 10. *Prasieæ*. Achenia fleshy, baccate. Example, *Prasium*. Tribe 11. *Ajugoideæ*. Lower lip of corolla much elongated; stamens ascending, superior two shortest or abortive. Examples, *Amethystea, Teucrium, Ajuga*.

181. *Verbenaceæ*, Jussieu.—Calyx tubular, persistent; corolla tubular, deciduous; limb usually irregular; stamens generally four, didynamous, rarely equal, or only two; ovarium two to four-celled; ovula erect, solitary, or twin; style one; stigma bifid or undivided; fruit drupaceous or baccate; albumen wanting or sparing; embryo erect. Composed of trees and shrubs, rarely herbs; leaves opposite, simple, or compound, without stipulas; flowers oppositely corymbose, or alternate and spicate, sometimes capitately crowded, rarely axillary and solitary. The famous teak of India is the wood of *Tectona grandis*. The lemon fragrance of *Verbena triphylla* is well known. Some of the plants are very ornamental. Examples, *Clerodendron, Vitex, Holmskioldia, Citherexylum, Duranta, Lantana, Tectona, Verbena, Lippia, Stachytarpheta*.

182. *Myoporinæ*, R. Brown.—Calyx five-parted, persistent; corolla almost equal or bilabiate; stamens four, didynamous, and sometimes with the rudiment of a fifth, which is rarely polliniferous; ovarium two to four-celled; cells one to two-seeded; ovula pendulous; style one; stigma hardly divided; drupe containing a two to four-celled putamen; the cells one to two-seeded; seeds albuminous; embryo terete; radicle superior. Composed of scarcely pubescent shrubs, natives of Australia; leaves simple, alternate or opposite, without stipulas; flowers axillary, without bracteas. Very nearly allied to *Verbenaceæ*, from which it differs in the albuminous seeds, pendulous ovula, and inflorescence. Examples, *Myoporum, Bontia, Stenochilus, Avicennia*.

183. *Selagineæ*.—Calyx tubular, rarely of two sepals, persistent; corolla tubular; limb irregular, five-lobed; stamens two or four, when the latter number they are didynamous; anthers one-celled; ovarium small; style filiform; fruit membranous, two-celled, one of the cells generally abortive; cells one-seeded; seed erect; albumen fleshy; radicle superior at the extremity, opposite to the hilum. Composed of herbs or subshrubs, native of the Cape of Good Hope, with alternate leaves, without stipulas, and spicate or corymbose inflorescence. This order differs from *Verbenaceæ* in the fleshy albumen and habit, and from *Myoporinæ* in the membranous not drupaceous fruit. Examples, *Selago, Hebenstreitia*.

184. *Acanthaceæ*, Jussieu.—Calyx four to five-parted or tubular, equal or unequal, persistent; corolla nearly regular or bilabiate; stamens two or four, when the latter is the case, they are didynamous, or two of them are abortive; anthers two-celled; cells with an equal or unequal insertion, or one-celled and dehiscing lengthwise; ovarium girded by a glandular disk, two-celled; cells two or many-seeded; style one; stigma two-lobed, rarely undivided; capsule two-celled, elastically two-valved; cells two or many-seeded, and sometimes one-seeded; dissepiment contrary, bipartible through the axis, the segments adnate to the valves, entire, rarely bipartible, bearing the seeds on the inner margin; seeds roundish, with ascending, subulate processes, for the most part suspended from the dissepiment; testa loose; albumen none; embryo curved or straight; cotyledons large; radicle centripetal. Composed of herbs or shrubs, with opposite leaves and variable inflorescence. The elastic dehiscence of the capsules and retinacula of the seeds separate this order readily from all its allies. The order is divided by Nees ab Esenbeek into two tribes. Tribe 1. *Thunbergieæ*. Seeds propped by retinacula, which are dilated at the apex into a horny cup, which is adnate to the seed. Example, *Thunbergia*. Tribe 2. *Nelsonieæ*. Retinacula of seeds contracted into the form of papillæ, which bear, but do not prop the seeds, which are small and scrobiculate. Examples, *Nelsonia, Hygrophila, Ruellia, Barleria, Acanthus, Justicia, Blechnum, Dicliptera, Hypoestes*.

185. *Lentibulariæ*, Richard.—Calyx divided, persistent; corolla irregular, spurred, bilabiate; stamens two, inserted in the bottom of the corolla; anthers simple, sometimes constricted in the middle; ovarium one-celled; style very short; stigma bilabiate; capsule one-celled, many-seeded; placenta large, central; seeds small; albumen none; embryo sometimes undivided. Composed of aquatic or marsh herbs; leaves radical, undivided, or compound, root-formed and bearing vesicles. Scapes furnished with minute stipulaformed scales, or without, and sometimes with whorls of vesicles, usually undivided, one-flowered, or spicately, or racemosely many flowered; flowers usually furnished each with a single bractea, rarely without. The embryo is undivided in *Utricularia*, but in *Pinguicula* plainly dicotyledonous, ex R. Brown. The large central placenta separates this order from all the foregoing irregular flowered orders; and the two-valved capsule, irregular flowers, and exalbuminous seeds separate it readily from the next order, *Primulaceæ*.

186. *Primulaceæ*, Ventenat.—Calyx five, rarely four-cleft, regular, persistent; corolla regular, with a five, rarely four-cleft limb; stamens five, rarely four, opposite the petals; ovarium one-celled; style one; stigma capitate; capsule valvate; placenta central, free; seeds numerous, peltate; albumen none; embryo enclosed, parallel with the umbilicus, having a common radicle. Composed of herbs, with usually opposite but sometimes verticillate or scattered leaves, but in *Primula* and others generally radical. *Samolus* has five alternate sterile stamens, and the ovarium not altogether free. In character this order comes nearest to *Myrsineæ*, but differs from it in habit and capsular fruit. The stamens being opposite to the lobes of the corolla, and the regular flowers separate it from the foregoing order, with which it only agrees in the placentation of the seeds and want of albumen. The Cowslip, Primrose, Polyanthus, Auricula, and Cyclamen are well-known plants of this order.



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Examples, *Cyclamen*, *Primula*, *Trientalis*, *Hottonia*, *Androsace*, *Cortusa*, *Soldanella*, *Lysimachia*, *Anagallis*, *Centunculus*, *Glaux*.

187. *Sibthorpiaceæ*, D. Don.—Calyx four to five-parted, persistent; corolla rotate, four to eight-cleft, regular, deciduous, with an imbricate æstivation; stamens four or eight, equal; anthers two-celled; cells parallel; style one; stigma capitate, undivided; capsule two-celled, two-valved, many-seeded; placenta large, spongy, globose, central; albumen fleshy; embryo terete, erect, enclosed; radicle long, terete, contrary to the umbilicus. Composed of herbs with alternate leaves and axillary, solitary, pedunculate flowers. This small family is distinguished from *Primulaceæ* in the stamens alternating with the lobes of the corolla, and in the two celled capsule. Examples, *Sibthorpia*, *Disandra*, *Scoparia*, *Romnnzovia*, *Xuaresa*.

188. *Globularineæ*, De Candolle.—Calyx five-cleft, equal, seldom bilabiate, persistent; corolla tubular, five-parted, bilabiate, rarely unilabiate; stamens four, rather unequal, inserted at the top of the tube; anthers reniform, one-celled; ovarium one-celled; ovula solitary, pendulous; style filiform, persistent; stigma bifid; fruit indehiscent; embryo straight in the axis of a fleshy albumen; radicle superior. Composed of herbs or undershrubs, with alternate, exstipulate leaves and capitate flowers, which are seated on paleaceous, bracteated receptacles. The leaves of *Globularia alypum* are bitter, purgative, and stomachic. Some botanists consider this order to come near to *Selagineæ* and *Primulaceæ*, and others to *Dipsaceæ* and *Brunoniaceæ*; with the two latter it agrees best in habit, as it does with *Armeria* in *Plumbagineæ*. Example, *Globularia*.

189. *Plumbagineæ*, Jussieu.—Calyx tubular, plicate, persistent; corolla monopetalous or of five petals, equal; stamens definite, hypogynous in monopetalous flowers, but in the polypetalous flowers they are epipetalous; ovarium one-seeded; ovulum inverted, hanging from the apex of a funicle, which rises from the bottom of the ovarium; styles usually five, rarely three or four; stigmas the same number; fruit an almost valveless utriculus; seed inverted; testa simple; albumen farinaceous; embryo straight; radicle superior. Composed of herbs and undershrubs, variable in habit; leaves alternate or crowded, undivided, somewhat sheathing at their bases; flowers spicate or capitate. *Plumbago* is caustic and acrid. The roots of *Statice* are said to be astringent and tonic. Examples, *Plumbago*, *Statice*, *Armeria*.

190. *Plantagineæ*, Jussieu.—Calyx four-parted, persistent; corolla tubular, scarious, persistent; limb four-parted; stamens four, protruded, doubled up in æstivation; anthers two-celled; cells opposite, contiguous; ovarium simple, two or four-celled; style capillary; stigma rather hispid, usually undivided, rarely semibifid; capsule circumscissed, with a longitudinal dissepiment, which is at length free, and seminiferous fascia; seeds sessile, peltate, solitary or twin, and often indefinite; testa mucilaginous; albumen fleshy; embryo slender, straight, almost the length of the albumen; radicle inferior. In *Littorella* the flowers are monoecious, and the stamens in the male flowers are hypogynous and not epipetalous, and in the female flower the ovarium is one-seeded, and the ovula erect. Composed of herbs with short or no stems. The radical leaves are crowded in the stemless species, and are either entire, toothed, or cut, generally flat and nerved, seldom semiterete, having the axils sometimes woolly; scapes axillary, rarely terminal, undivided; flowers usually spicate, rarely sub-solitary, sessile, each furnished with a bractea. *Plantago* is bitter, astringent, and febrifugal. Examples, *Plantago* and *Littorella*.



Fourth subclass. *Monochlamydeæ*, De Candolle.—Flowers consisting of a single perianth or perigone, which is either green or coloured, and may be considered as a calyx when the stamens are opposite its lobes, and as a corolla when the stamens alternate with its lobes.

First division. *Hypostamineæ*, Jussieu.—Stamens hypogynous.

191. *Nyctagineæ*. Jussieu.—Perianth tubular, a little coloured, coarctate in the middle; limb entire or toothed, with a plicate æstivation; stamens definite, hypogynous; anthers two-celled; ovarium single, free, one-seeded; ovulum erect; style one; stigma one; fruit a slender utricle, enclosed in the perianth, with an increased, persistent tube; seed destitute of an integument; testa adnate to the utricle; albumen amylaceous in the recess of the embryo, which has foliaceous cotyledons and an inferior radicle. Composed of herbs, shrubs, and trees. Leaves opposite and usually unequal in size, sometimes alternate; flowers axillary or terminal, crowded or solitary, furnished with a one or many-leaved involucrum, which is sometimes minute. The roots are generally purgative. Examples, *Oxybaphus*, *Mirabilis*, *Abronia*, *Boerhavia*, *Allionia*, *Pisonia*.

192. *Amaranthaceæ*, Jussieu.—Perianth three to five-parted, scarious, persistent, usually bibracteate; stamens equal in number to the segments of the perianth, distinct or combined, often with alternate, sterile processes or filaments; anthers one or two-celled; ovarium single, free, one-celled; ovula solitary or many, suspended from a free central funiculus; style one or absent; stigma simple or compound; fruit an utricle, rarely a berry; seeds lentiform, pendulous; testa crustaceous; embryo curved round the albumen, which is farinaceous; radicle near the hilum. Composed of herbs and shrubs, with opposite or alternate exstipulate leaves, and capitate or spicate flowers. Martius considers the bracteoles a calyx, and the perianth a corolla, which would bring it close to *Illecebreæ*. The plants of this order are extremely showy, for which reason they are generally cultivated. Properties emollient and demulcent, the leaves being mucilaginous. Tribe 1. *Amarantheæ*. Flowers all evolute; stigma divided or multiple. Examples, *Deeringia*, *Amaranthus*, *Celosia*, *Gomphrena*, *Oplothera*. Tribe 2. *Achyrantheæ*. Flowers all evolute; stigma undivided. Examples, *Alternanthera*, *Achyranthes*. Tribe 3. *Desmochæteæ*. Flowers not all evolute. Example, *Desmochæta*.

Second division. *Peristamineæ*, Jussieu.—Stamens perigynous.

193. *Chenopodeæ*, De Candolle.—Perianth deeply divided, sometimes tubular at the base, persistent, with an imbricate æstivation; stamens inserted in the bottom of the perianth, and equal in number to its segments, and opposite them, or fewer; ovarium free, rarely adhering to the tube of the perianth, one-seeded; ovulum erect or inverted, fixed to the bottom of the cell; style two or four-cleft, rarely simple; stigmas undivided; pericarp membranous, valveless, and sometimes baccate; embryo curved and encircling a farinaceous albumen or spiral, or two-legged without albumen; radicle in the region of the umbilicus. Composed of herbs and undershrubs, with usually alternate, rarely opposite leaves,

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without stipulas; flowers small, often unisexual. Hardly to be distinguished from *Amoranthaceæ*, unless in habit and insertion of stamens. Spinach and Beet-root belong to this order. *Salsola* and some others yield soda. Examples, *Basella*, *Salsola*, *Chenopodium*, *Atriplex*, *Rhagodia*, *Beta*, *Spinacia*, *Corispermum*, *Blitum*, *Salicornia*, *Camphorosma*, *Axyris*.

194. *Phytolacaceæ*, R. Brown.—Perianth two, four, or five-parted; stamens inserted into the base of the perianth, equal in number to its segments or indefinite, when the former is the case they alternate with the segments; ovarium solitary, or of several joined carpels; ovula one in each carpel, terminal in simple ovarium, and lateral in the syncarps; stigmas simple, pencilled, or divided; fruit baccate or dry, indehiscent; seeds solitary, ascending or erect; albumen mealy, rarely fleshy, or wanting; embryo curved round the albumen when present, but straight when absent; radicle inferior or next the hilum. Composed of herbs or shrubs, with alternate leaves, often with minute pellucid dots, and axillary, lateral, or terminal racemes or spikes of small insignificant flowers. *Phytolacca decandra*, the Virginian-Poke, is purgative, the root emetic, and the young shoots are used instead of Asparagus. The order is divided into two tribes. Tribe 1. *Phytolaceæ*. Stamens definite or indefinite; ovarium of one or several carpels; stigmas simple or divided; albumen fleshy or mealy; embryo curved round the albumen; radicle next the hilum; leaves exstipulate. Examples, *Phytolacca*, *Rivina*, *Giesekia*. Tribe 2. *Petiveriæ*. Stamens indefinite; ovarium solitary, one-celled; ovulum erect; style lateral; stigma simple or pencilled; fruit dry, one-celled, indehiscent; seed erect; albumen none; leaves furnished with minute deciduous stipulas. Examples, *Petiveria* and *Sequiera*.

195. *Polygoneæ*, Jussieu.—Perianth one-leaved, divided, with an imbricate æstivation; stamens definite, inserted in the base of the perianth; cells of anthers dehiscing lengthwise; ovarium free, one-seeded; ovulum erect; styles or stigmas numerous; fruit naked, or covered by the perianth; albumen mealy, rarely almost absent; embryo inverted, usually unilateral. Composed of herbs or shrubs; leaves alternate, sheathing at their bases, or adnate to the intrafoliaceous sheaths; when young revolute beneath; flowers usually of separate sexes, and generally racemose. Properties tonic and purgative. Rhubarb, French Sorrel, and Buckwheat belong to this order. The erect ovulum and superior radicle readily separate this family from *Phytolacaceæ* and *Chenopodeæ*. Tribe 1. *Persicariæ*. Flowers solitary; embryo usually unilateral; leaves sheathing or adnate to the intrafoliaceous stipulas, revolute in the young state. Examples, *Coccoloba*, *Polygonum*, *Atraphaxis*, *Oxyria*, *Rumex*, *Triplaris*, *Rheum*, *Fagopyrum*. Tribe 2. *Eriogoneæ*. Flowers collected into a campanulate involucrum; embryo straight in the axis of the albumen; leaves woolly, entire, neither sheathing nor with intrafoliaceous stipulas. Example, *Eriogonum*.

196. *Begoniaceæ*, R. Brown.—Flowers of separate sexes; perianth three to nine-cleft in the males, and five or six-cleft in the females, the divisions usually unequal in size, with an imbricate æstivation; stamens indefinite, distinct, or monadelphous; anthers clavate, two-celled, with thick connectives; ovarium adhering to the tube of the perianth, composed of three carpels, therefore three-celled, each cell or carpel furnished with a wing on the back; ovula indefinite; stigmas three, sessile, two-lobed, rather spirally twisted; placentas in the axis; fruit capsular, membranous, three-celled, triangular, three-valved, dehiscing at the angles below; seeds numerous; testa reticulated; albumen none; embryo oblong; radicle next the hilum. Composed of fleshy herbs or subshrubs with alternate leaves, which are oblique at their bases, and of a different colour beneath, and furnished with scarious, sheathing stipulas; inflorescence dichotomous, panicled, terminal; leaves and shoots acid and wholesome; roots astringent. Very nearly related to the preceding order. Example, *Begonia*.

197. *Laurineæ*, Jussieu.—Perianth four to six-cleft, with an imbricate æstivation, but the limb is sometimes obsolete; stamens definite, perigynous, opposite the segments of the perianth; often double their number, in two series, the three opposite the segments of the perianth are deficient or sterile, and the six inner ones rarely abortive; anthers adnate, two or four-celled; cells dehiscing each by a longitudinal, persistent valve from base to apex, outer row bursting inwards, and the inner row outwards; there are glands in most of the genera at the base of the inner filaments; ovarium simple, free, one-seeded; ovulum pendulous; style simple; stigma obtuse; berry or drupe naked or covered; albumen none; embryo inverted; cotyledons large, plano-convex, peltate near the base; radicle very short, enclosed, superior. Composed of tall trees; leaves alternate, rarely opposite, without stipulas, entire, rarely lobed; inflorescence panicled or umbellate; in some that are parasitical subshrubs or herbs they are leafless, twining, and the flowers are spicate and tribracteate, as *Cassytha*. Cinnamon, Cassia, Camphur, Benzoin, Sassafras, and other spices, belong to this order. The Alligator or Avocado Pear is a remarkable fruit. Examples, *Laurus*, *Cinnamomum*, *Persea*, *Tetranthera*.

198. *Hernandiaceæ*, Blume.—Flowers of separate sexes; perianth four or eight-parted, deciduous, propped by a small involucrum or outer perianth which contains the pistils; stamens perigynous, definite, in two rows, the outer row often sterile; anthers two-celled; ovarium simple, one-celled, one-seeded; ovulum pendulous; style present or absent; stigma peltate; fruit a fibrous drupe; seed solitary, pendulous; albumen none; radicle superior; cotyledons a little lobed, oily. Composed of tall trees with alternate, entire, usually peltate leaves. The seeds of *Inocarpus* are eaten under the name of Otabeite Chestnuts. *Hernandia* is rather purgative. The want of albumen separates this order from *Myristiceæ*, and the form of the anthers from *Laurineæ*.

199. *Illigereæ*, Blume.—Flowers hermaphrodite or polygamous by abortion; tube of perianth adnate to the ovarium; the limb divided into a double series of segments, which are valvately inflexed in æstivation, and deciduous, or partly so; stamens rising from the top of the tube of the calyx, opposite the outer series of segments, and equal to them in number, furnished with a gland or appendage each on both sides at the base, or the glands are placed between them; anthers two-celled; cells bursting inwards from base to apex by a persistent valve; ovarium inferior, one-celled, ovulum solitary, pendulous; style undivided; stigma peltate, obtuse, or rather oblique; fruit indehiscent; seed mucumentaceous; albumen none; cotyledons foliaceous, contortuplicate. Composed of climbing shrubs and tall trees with alternate, simple, lobed, or ternate, exstipulate leaves, and cymosely-panicled inflorescence. Examples, *Illigera*, *Gyrocarpus*.

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200. *Myristiceæ*, R. Brown.—Flowers dioecious; perianth trifid, with a valvular æstivation: male flower having the filaments combined into a column; anthers three to twelve, two-celled, bursting outwards; cells connate or distinct: female flower; perianth deciduous; ovarium free, sessile, one-seeded; ovulum erect; style very short; stigma a little lobed; fruit a one-celled, two valved berry; seed nucumentaceous; arillus many-parted; albumen ruminated, of a fatty-fleshy substance; embryo small; cotyledons foliaceous; radicle inferior. Composed of tropical trees yielding a reddish, acrid juice on being cut; leaves alternate, exstipulate, quite entire, dotless, petiolate, coriaceous; inflorescence usually axillary and terminal, racemose, glomerate, or panicled; flowers propped by a short, cucullate bractea each; perianth tomentose outside. The Mace of the shops is the arillus, and the Nutmeg is the albumen of *Myristica officinalis*. The Guiana Wax is the produce of *Virola sebifera*. The fleshy part of the fruit is caustic. Examples, *Myristica* and *Virola*.

201. *Proteaceæ*, Jussieu.—Perianth three-leaved or four-cleft, with a valvate æstivation; stamens perigynous, four, one of which is sometimes sterile, opposite the leaflets or segments of the perianth; ovarium single, free; style simple; stigma subundivided, discoid; fruit dehiscent or indehiscent, one-celled; seed sometimes winged; testa thick; albumen none; embryo straight; radicle inferior; cotyledons often divided. Composed of handsome shrubs or small trees, natives of South Africa and Australia, with usually hard, dry, opposite, or alternate leaves without stipulas; inflorescence variable, amentaceous, spicate or racemose. This is so very distinct an order that it cannot be confounded with any other. Examples, *Leucodendron*, *Protea*, *Adenanthos*, *Grevillea*, *Hakea*, *Lambertia*, *Telopia*, *Stenocarpus*, *Banksia*, and *Dryandra*.

202. *Thymelææ*, Jussieu.—Perianth free, tubular, coloured; limb four-cleft, rarely five-cleft, with an imbricate æstivation, and often with scales in the throat; stamens definite, usually eight, sometimes four, but rarely two, inserted in the throat of the tube, and when equal in number to the segments of the perianth, or fewer, they are opposite them; anthers two-celled; cells dehiscing lengthwise in the middle; ovarium simple, one-seeded; ovulum pendulous; style one; stigma undivided; fruit nucumentaceous or drupaceous; albumen thin, fleshy, or absent; embryo straight, inverted; cotyledons plano-convex; radicle short, superior. Composed of elegant shrubs with alternate or opposite, quite entire, exstipulate leaves; flowers capitate or spicate, terminal or axillary, seldom solitary. The bark is acrid. The inner bark is easily separable; that of *Dapne Lagetta* pulls off into a sort of network resembling lace, which is worked into cordage; that of some others is made into paper. *Mezereon* and Spurge Laurel are poisonous. Examples, *Dirca*, *Daphne*, *Gnidia*, *Lachnæa*, *Passerina*, *Dais*, *Struthiola*, *Pimelea*.

203. *Penæaceæ*, R. Brown.—Perianth coloured deeply, four-cleft, persistent; stamens perigynous, four or eight, alternating with the segments of the perianth; anthers two-celled, dehiscing inwards; ovarium one, free, four-celled; ovula two in each cell, collateral, erect, or pendulous; style one, entire or four-cleft; stigmas four or one, entire, or four-lobed; fruit a four-celled, four-valved, loculicidal capsule; seeds erect or pendulous, two in each cell, rarely solitary, with an imperfect fungous-like arillus at the hilum; testa brittle; nucleus fleshy; radicle next the hilum. Composed of small shrubs with opposite, simple, entire, exstipulate leaves; flowers in heads, usually propped by two or more bracteas each. This order is very closely allied to *Thymelææ*, from which it differs in the characters given. *Sarcocolla*, a gum resin, is obtained from several species of *Penæa* and *Sarcocolla*.



204. *Elæagneæ*, Jussieu.—Flowers dioecious or hermaphrodite; perianth tubular; the limb entire, or two or four-toothed, persistent; stamens three, four, or eight, alternating with the segments of the perianth; anthers almost sessile, two-celled, dehiscing inwards; ovarium free, one-celled; ovulum solitary, ascending on a short funicle; style short; stigma simple, subulate, glandular, or tongue-shaped; fruit crustaceous, enclosed in the pulpy, persistent, enlarged tube of the perianth; embryo straight; albumen thin and fleshy; radicle short, inferior; cotyledons fleshy. Composed of trees and shrubs covered with silvery scales, especially on the under sides of the leaves, young branches, and calyxes; leaves entire, alternate, or opposite, without stipulas; flowers axillary and lateral, solitary or aggregate, usually yellow. The fleshy part of the fruit is the increased perianth, and in some species it is eaten and extremely agreeable. Examples, *Hippophae*, *Shepherdia*, *Elæagnus*.

205. *Osyrideæ*, or *Exocarpeæ*.—This order only differs from *Santalaceæ*, of which it is probably only a tribe, in the stamens being perigynous, and in the fruit being superior. It is composed of shrubs and trees with alternate, exstipulate leaves. Examples, *Exocarpus*, *Anthobolus*, and *Osyris*.

206. *Aquilarineæ*, R. Brown.—Perianth coriaceous, tubular, five-lobed; stamens monadelphous, twenty, ten of which are fertile, and the other alternate ten are sterile, and sometimes petaloid; anthers erect, two-celled; ovarium free, ovate, formed of two carpels, one-celled, two-ovulate; ovula suspended, acuminated, with the foramen at the apex; stigma sessile, simple; placentas parietal; capsule pear-shaped, one-celled, two-valved; seeds two, one to each placenta, arillate or winged. Composed of trees with alternate, entire leaves without stipulas. The parietal placentation of the seeds is sufficient to separate this order from all its allies. In some points it agrees with *Chailletiaceæ* and *Thymelææ*. Examples, *Aquilaria*, *Ophispermum*, *Gyronops*.

207. *Chailletiaceæ*, De Candolle.—Perianth five-cleft, coloured inside, with an imbricate æstivation; stamens ten, rising from the bottom of the perianth, distinct or connected at the base, the five alternate ones sterile, petal-like, and often bifid, the fertile five opposite the lobes of the perianth; glands numerous, opposite; anthers two-celled, roundish; ovarium free, hairy, two to three-celled; cells biovulate; styles two to three, distinct or connected; stigmas the same number, capitate; drupe dry, coriaceous, downy, containing a two or three-celled nut, or only one to two-celled by abortion; seeds solitary in the cells, pendulous; albumen none; embryo thick; radicle short, superior; cotyledons fleshy. Consisting of tropical shrubs with entire, alternate, histipulate leaves; peduncles axillary, bearing panicled racemes of small white flowers, usually adnate to the petioles. Readily distinguished from *Aquilarineæ* by the drupaceous fruit and stipulate leaves. The kernel of the fruit of *Chailletia toxicaria* is poisonous. Examples, *Chailletia*, *Tapura*.

208. *Samydeæ*, Gærtner.—Perianth three to seven, but generally five-parted, petal-like, and coloured inside; lobes

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more or less connected at their bases, usually imbricate, rarely valvate in æstivation; stamens rising from the perianth, double, triple, or quadruple the number of the lobes of the perianth, flat and monadelphous at their bases, and subulate at their apices, all bearing anthers, or the alternate ones are sterile, villous, or fringed; anthers ovate, two-celled, inserted by their bases, erect; style filiform; stigma capitate or lobed; capsule coriaceous, three to five-valved, many-seeded; seeds ovate, baccate, umbilicate, fixed to the pulpy part of the valves; albumen fleshy; embryo inverted; cotyledons plicate, foliaceous; radicle contrary to the umbilicus of the seed. Composed of tropical shrubs or small trees, with alternate, stipulate, entire or toothed, persistent leaves, usually full of pellucid dots, and arranged in a distich manner; peduncles axillary, solitary or aggregate, one or many-flowered. This is readily distinguished from the allied orders by several of the characters given. Examples, *Samyda*, *Casearia*.

209. *Homalineæ*, R. Brown.—Perianth with an obconical tube; limb five, ten, or fifteen-parted, usually alternating with as many petaloid segments, either in the same row or forming an inner row, usually with a valvate æstivation; there is a gland or scale generally in front at the base of each of the proper lobes of the perianth; stamens rising between these glands, and therefore opposite the proper lobes of the perianth, sometimes equal in number to them, but usually from three to seven times that number, and disposed in fascicles; anthers two-celled, didymous; ovarium conical, one-celled, partly connected with the tube of the perianth at the base; ovula numerous; styles three to five, simple; fruit capsular or baccate; placentas parietal, equal in number to the styles, many-seeded; seeds small; albumen fleshy; embryo in the axis; radicle inferior, pointing to the hilum; cotyledons foliaceous. Composed of shrubs and trees with alternate, entire or toothed, stipulate leaves, the stipulas usually deciduous, and spicate, racemose, or panicled inflorescence. This order agrees with *Rosaceæ* in the insertion of the stamens, but with *Samydeæ*, *Bixineæ*, and *Flacourtianeæ* in the structure of the fruit and the parietal placentas. Examples, *Homalium*, *Azara*, *Pineda*, *Blackwellia*, *Nisa*, *Astranthus*.

Third division. *Epistamineæ*, Jussieu.—Stamens epigynous.

210. *Santalaceæ*, R. Brown.—Perianth superior, four to five-cleft, coloured inside, with a valvate æstivation; stamens four to five, opposite the segments of the perianth, and inserted in their bases; ovarium one-celled, inferior, two to four-seeded; ovula pendulous, fixed near the apex of the central placenta; style one; stigma generally lobed; fruit one-seeded, nucumentaceous or drupaceous; albumen fleshy; embryo slender, inverted, terete. Composed of shrubs and trees, rarely of undershrubs; leaves alternate or nearly opposite, without stipulas, undivided, sometimes minute and stipula-formed; flowers subspicate, rarely umbellate or solitary, always small. *Santalum album* affords the Sanders Wood. Tribe 1. *Santaleæ*. Ovula numerous, two to four, from near the apex of the central placenta; flowers hermaphrodite. Examples, *Santalum*, *Fusanus*, *Thesium*. Tribe 2. *Nysseæ*. Ovula one or two, hanging from the apex of the cavity, not being furnished with a central placenta; flowers polygamous. Examples, *Nyssa*, *Hamiltonia*.

211. *Aristolochiæ*, R. Brown.—Perianth superior, three-cleft, equal or unequal; stamens definite; ovarium inferior, many-celled; cells many-seeded; style very short; stigma stellately divided; fruit capsular or baccate; seeds numerous; albumen dense, fleshy; embryo small, undivided, enclosed in the umbilical region of the albumen. Composed of herbs or shrubs, usually climbing; leaves alternate; stipulas often foliaceous; flowers axillary, solitary, hermaphrodite, of a singular structure. The roots are bitter and acrid. *Asarum* is purgative and emetic. *Aristolochia* is tonic and stimulating. Examples, *Aristolochia* and *Asarum*.

212. *Cytineæ*, R. Brown.—Perianth divided or four-parted, with an imbricate æstivation; male flower containing a solid central column, from the top of which, in the tribe *Rhizantheæ*, rise some horned processes, anthers cohering with the column, or collected into a spherical head on the top of the column; anthers bursting outwards longitudinally, or by terminal pores; ovarium free, or cohering with the tube of the perianth, one-celled, but spuriously four-celled in the superior ovarium; placentas parietal; ovula indefinite; fruit a capsule, with a loculicidal dehiscence, or a pulpy berry; seeds numerous, minute. Composed of singular parasitical or terrestrial plants, with unisexual flowers. This order is divided into two very distinct tribes. Tribe 1. *Rhizantheæ*, Blume. Perianth divided; anthers cohering with the central column, from the apex of which rise some horned processes; ovarium cohering with the tube of the perianth, one-celled; placentas several, broad, parietal; fruit a pulpy berry; seeds indefinite, minute. Parasitical plants, with simple stems and scale-like leaves. Examples, *Cytinus* and *Rafflesia*. This last is considered the largest known flower, and is a native of Sumatra. Tribe 2. *Nepentheæ*, Link. Perianth four-parted; anthers about sixteen, sessile, and glomerated into a spherical head at the apex of the column; ovarium superior, four-cornered, spuriously four-celled in consequence of the protruding, parietal placentas; fruit capsular, four-celled, four-valved, loculicidal; seeds minute, with a filiform process at each extremity; albumen fleshy; embryo oblong; radicle pointing to the hilum; cotyledons plano-convex. Climbing plants, the leaves of which have their extremities hollowed out into pitcher-shaped appendages, each closed by a lid, and usually filled with water; flowers small, densely racemose. Example, *Nepenthes*, or Pitcher Plant.

213. *Cephaloteæ*, R. Brown.—Perianth six-cleft, coloured, with a valvate æstivation; stamens twelve, inserted in the perianth; anthers didymous, glandular on the back; ovaria six, distinct, each terminated by a style; achenia one-seeded; seed erect; albumen none. This order consists of a single known plant, the *Cephalotus follicularis*; it is an almost stemless herb, a native of marshes in New Holland; the leaves are all radical and stalked, some of which are elliptical and flat, and others are dilated into the shape of pitchers like those of *Nepenthes*, which are generally filled with water and closed by a lid each. The scape is erect, and bears at its apex a panicle of small white flowers.

Fourth division. *Diclines-Angiospermæ*, Jussieu.—Flowers unisexual, and often destitute of a perianth; seeds enclosed in a capsule.

214. *Datisceæ*, R. Brown.—Flowers dioecious: male flower; perianth divided into four or five parts; stamens several, four to fifteen, hypogynous; anthers two-celled: female flowers; perianth toothed; ovarium inferior, one-

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celled; ovula indefinite; styles three to four; stigmas simple; placentas equal in number to the styles, parietal; capsule one-celled, dehiscing at top; albumen none; embryo straight, terete; radicle pointing to the hilum; cotyledons short. Composed of coarse herbs having the habit of hemp, with alternate, pinnate leaves without stipulas, and long-spiked racemes of yellowish flowers. Examples, *Datisca* and *Tetrameles*.

215. *Euphorbiaceæ*, Jussieu.—Flowers of separate sexes; perianth lobed or wanting, furnished on the inside by various hypogynous, glandular, or scale-formed appendages: male flower; stamens definite or indefinite, distinct or monadelphous; anthers two-celled: female flower; ovarium superior, sessile or stipitate, of two, three, or more cells; the cells or carpels arranged round a central column; styles equal in number to the cells, distinct or combined, seldom wanting; ovula solitary or in pairs, pendulous; stigmas many, distinct, or combined into a many-lobed one; capsule of two, three, or more usually distinct cells or cocci, which are elastically two-valved; seeds solitary or in pairs, suspended, arillate, fixed to the top of the central placenta; albumen fleshy; embryo enclosed; radicle superior; cotyledons flat. Composed of herbs or shrubs which are often lactescent; leaves usually alternate and furnished with stipulas, seldom wanting; flowers axillary or terminal, bracteate or involucrated, the involucrum or bracteas coloured. The milky juice of all is poisonous, which may be expelled by heat, so that the root of the Manioc or Cassada becomes wholesome food. The *Tiglium*, Castor Oil plant, and Caoutchouc, are of this order. The order is divided into six different tribes. Tribe 1. *Buxeæ*. Cells of ovarium biovulate; stamens definite, sessile, inserted under the central rudiment of the style. Examples, *Drypetes*, *Pachysandra*, *Buxus*, *Sarcacocca*, *Fluggea*. Tribe 2. *Phyllantheæ*. Cells of ovarium biovulate; stamens definite, inserted in the centre of the flower; flowers glomerate, fascicled, or subsolitary. Examples, *Cicca*, *Emblica*, *Kirganelia*, *Phyllanthus*, *Xylophylla*, *Cluytia*. Tribe 3. *Crotoneæ*. Cells of ovarium uniovulate; stamens definite or indefinite; flowers usually corollate, fascicled, spicate, racemose, or panicled. Examples, *Croton*, *Ricinus*, *Iatropha*, *Aleurites*, *Siphonia*. Tribe 4. *Acalypheæ*. Cells of ovarium uniovulate; stamens definite or indefinite; flowers apetalous, glomerately spicate, rarely subracemose. Examples, *Mappa*, *Mercurialis*, *Acalypha*, *Tragia*. Tribe 5. *Hippomaneæ*. Cells of ovarium uniovulate; stamens definite; flowers apetalous; bracteas large, many-flowered, spicate, or amentaceous. Examples, *Sapium*, *Stillingia*, *Hippomane*, *Hura*, *Omphalea*. Tribe 6. *Euphorbieæ*. Cells of ovarium uniovulate; flowers apetalous, monoecious, in a common involucrum. Examples, *Dalechampia*, *Euphorbia*.

216. *Urticaceæ*, Jussieu.—Flowers small, of different sexes, solitary, amentaceous, or within an involucrum; perianth three to five-lobed, persistent: male flower; stamens definite, inserted into the base of the perigone: female flower, ovarium simple, free; styles two, bifurcate; achenia surrounded by the membranous or fleshy, persistent perianth, or inserted into a fleshy receptacle, which is dilated and often concave; seed solitary, erect, orthotropous; albumen none; embryo inverted; radicle superior, at the opposite extremity of the seed from the hilum. Composed of trees, shrubs, and herbs; leaves usually alternate and hispid, rarely opposite or smooth, always stipulate; inflorescence variable, but generally capitate or racemose. The Hemp, the Hop, and Nettle belong to this order, which has been divided into the following tribes by Gaudichaud. Tribe 1. *Elatostemmæ*. Example, *Elatostemma*. Tribe 2. *Urereæ*. Examples, *Urtica*, *Urera*. Tribe 3. *Bœhmerieæ*. Example, *Bœhmeria*. Tribe 4. *Parietarieæ*. Example, *Parietaria*. Tribe 5. *Forskălieæ*. Example, *Forskălia*. Tribe 6. *Cecropieæ*. Examples, *Cecropia*, *Musanga*. Tribe 7. *Cannabineæ*. Examples, *Cannabis*, *Humulus*. Tribe 8. *Dorstenieæ*. Example, *Dorstenia*. Tribe 9. *Musandreæ*. Examples, *Musandra*, *Gunnera*.



217. *Artocarpeæ*, R. Brown.—Flowers unisexual, disposed in heads or catkins; perianth usually divided, but sometimes also tubular and entire; stamens solitary or several, straight during æstivation; ovarium free, seldom cohering to the perianth, one or two-celled; ovulum erect, orthotropous; style one, filiform; stigma bifid; fruit a sorosis or sycoo, which is sometimes, though rarely, reduced to a single carpel; seed solitary, erect; albumen thin or inconspicuous; embryo straight or curved; radicle pointing, superior. This order is composed of trees and shrubs abounding in milky juice; leaves alternate; stipulas deciduous, convolute in vernation. The fruit of the greater number of this order are edible, as the Bread Fruit, Fig, Mulberry, but the juice is generally acrid, and contains more or less of caoutchouc. The *Antiaris toxicaria*, the celebrated Upas Tree of Java, also belongs to this order, as well as the *Brosimum Galactodendron*, or the Cow Tree of South America, whose milky juice is wholesome. The *Ficus religiosa*, also a plant of this order, is the Indian Banyan Tree. Examples, *Artocarpus*, *Morus*, *Broussonetia*, *Maclura*, *Brosimum*, *Antiaris*, *Ficus*.

218. *Stilagineæ*, Agardh, or *Antidesmeæ*.—Flowers dioecious; perianth three to five-parted; stamens two to six, hypogynous; anthers erect, two-lobed, with a fleshy connective, and vertical, transverse cells; ovarium superior, containing two ovula; stigma sessile, three to four-toothed; fruit drupaceous; seed solitary by abortion, drupaceous; embryo in the axis of a fleshy albumen; cotyledons foliaceous. Composed of trees and shrubs with alternate leaves, deciduous stipulas, and axillary and terminal racemes of flowers; fruit edible, hanging like currants. Examples, *Stilago*, *Antidesma*. Closely allied to *Urticeæ*.

219. *Monimieæ*, Jussieu.—Flowers monoecious, the males and females crowded in separate involucra, the involucra toothed or lobed; perianth none; stamens in the male involucrum filling its whole interior; anthers two-celled; ovaria sessile, several together, each with a style and a stigma, the whole enclosed in the tube of the involucrum; ovulum solitary, pendulous; fruit dry; embryo in the axis of the albumen; radicle superior. Composed of trees and shrubs with opposite, exstipulate leaves, and short, axillary racemes of insignificant flowers. Bark, when bruised, aromatic. Examples, *Monimia*, *Boldoa*.

220. *Atherospermeæ*, R. Brown.—Flowers monoecious, the males and females generally collected in different involucra, being rarely in the same; the involucra tubular, divided, the divisions generally arranged in two rows, the inner row, and sometimes both, are petaloid, accompanied by a few scales in the female involucra; stamens very numerous in the male involucra, inserted in its base, and mixed with scales; anthers two-celled, dehiscing by a longitudinal valve; ovaria usually definite; ovulum solitary, erect; style rising from the side or base of each ovarium; stigma undivided; achenia

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enclosed within the enlarged tube of the involucrum, each furnished with the persistent style, which becomes at length feathery; albumen fleshy; embryo short at the base; radicle inferior. Composed of trees with opposite, exstipulate leaves, and axillary, solitary flowers. We have placed this beside *Monimiceæ*, as Mr. Arnott has done, and not as Mr. Brown, who considers the involucrum a perianth, which would bring it nearest to *Laurineæ*. Example, *Atherosperma*.

221. *Lacistemeæ*, Martius.—Perianth of several narrow divisions, covered by a dilated bractea; stamen one, hypogynous; anther two-celled, separated by a thick, two-lobed connective, dehiscing transversely; torus a fleshy disk; ovarium free, one-celled, containing several ascending ovula; style almost wanting; stigmas two to three or four, small, subulate, and spreading; placentas parietal; capsule two to three or four-valved, with a loculicidal dehiscence; seeds generally solitary by abortion, with a fleshy arillus, suspended by a long funicle; albumen fleshy; embryo with a straight, terete, superior radicle, and flat cotyledons. Composed of shrubs with alternate, exstipulate leaves, and axillary, aggregate catkins. This remarkable order is arranged near to *Chloranthæ* by Arnott. Example, *Lacistema*.

222. *Chloranthæ*, R. Brown.—Flowers hermaphrodite or unisexual; perianth tridentate; stamens lateral, if more than one combined; anthers two to four-celled; cells dehiscing lengthwise, adnate to a fleshy connective; filaments adhering slightly to the ovarium; ovarium one-celled; stigma simple, sessile; ovulum pendulous; fruit drupaceous, indehiscent; embryo minute, placed at the apex of a fleshy albumen; radicle inferior; cotyledons divaricate. Composed of herbs or undershrubs having an aromatic taste; stems tumid under the articulations; leaves opposite, with sheathing petioles and minute intervening stipulas; flowers in terminal, loose spikes. The want of a sac to the embryo, and the opposite leaves with intermediate stipulas, and pendulous ovulum, separate this order from *Piperaceæ* and *Lacistemeæ*. *Chloranthus officinalis* has a fragrant smell and bitter flavour, and is considered to be highly stimulant. Examples, *Chloranthus*, *Ascarina*, and *Hedyosmum*. The opposite leaves and intermediate stipulas bring this family near to *Rubiaceæ*.

223. *Piperaceæ*, Richard.—Each flower with a perianth or bractea; stamens definite or indefinite, hypogynous, or adhering more or less to the ovarium; anthers one to two-celled, with or without a fleshy connective; ovaria one or four, superior, or three to four-celled; ovulum erect or ascending, one in each carpel or cell; fruit fleshy, solitary or four together, or a capsule of one or three to four cells containing several ascending seeds; embryo minute, enclosed in a fleshy endosperm, placed on the outside of the albumen at the extremity remotest from the hilum. Composed of shrubs or herbs with opposite, alternate and whorled, stipulate or exstipulate leaves; flowers in dense spikes. Black Pepper, Cubebs, Betel, and several other peppers, are of this order, which is divided into two tribes. Tribe 1. *Piperineæ*. Stamens definite or indefinite, arranged on one side or around the ovarium, to which they adhere more or less; anthers with or without a fleshy connective; ovarium solitary, free, one-celled; ovulum solitary, erect; stigma sessile, oblique; fruit rather fleshy, one-celled; leaves opposite, rarely alternate or verticillate; flowers in spikes. Examples, *Piper*, *Piperomia*. Tribe 2. *Saurureæ*. Stamens three or six, clavate, hypogynous, or adhering to the angles of the ovarium; anthers continuous, with a thick connective, and two lobes, dehiscing lengthwise; ovaria four, or solitary and three to four-celled; in the first the ovula are solitary, and in the second several, ascending; stigmas recurved, one to each carpel or cell. Marsh or floating herbs with alternate stipulate leaves; flowers in spikes, having a four-leaved involucrum at the base of each spike. Examples, *Saururus*, *Aponogeton*, *Houttuynia*.

224. *Juglandeæ*, De Candolle.—Flowers monoecious, male ones disposed in aments, each with a scaly, oblique, two to six-lobed perianth; stamens hypogynous, indefinite; filaments short; anthers two-celled, innate, erect: female flowers with a double or single perianth, which adheres to the ovarium, the outer one four-cleft, and the inner one of four separate parts when present; ovarium one-celled; ovulum erect; styles one or two, or wanting; when this last is the case, the stigma is discoid and four-lobed, otherwise the stigmas are two; drupe fleshy, containing a two to four-valved, one-celled, rugged nut; seed with cerebriform convolutions, more or less four-lobed, covered by a membranous testa; albumen none; embryo large; radicle superior; cotyledons fleshy, two-lobed, wrinkled. Composed of trees with alternate, impari-pinnate, exstipulate leaves: female flowers terminal, one to three or more, in a loose spike: male flowers in close aments. In habit and fruit this order agrees with *Terebinthaceæ*. Walnuts belong to this family, the rinds of which are astringent. Examples, *Juglans*, *Carya*.

225. *Amentaceæ*, Jussieu.—Flowers unisexual, rarely hermaphrodite; male ones capitate, or in a catkin, furnished each with a scale; stamens inserted on the scale, rarely monadelphous; anthers two-celled: female flowers solitary, fascicled, or in a catkin, also furnished each with a scale; ovarium one, rarely more, free; stigmas numerous; fruit capsular or drupaceous; albumen none or thin; embryo straight or curved, flat; radicle usually superior. Composed of trees and shrubs, leaves alternate, stipulate when young; flowers generally amentaceous. The Oak, Willow, Filbert, Sweet Chestnut, Alder, Birch, Beech, Hornbeam, Plane-tree, Poplar, belong to this family, which is divided into several tribes and subtribes. Tribe 1. *Betulineæ*, Richard. Flowers hermaphrodite, polygamous or monoecious; perianth free, four to five-lobed; stamens four to twelve; when equal to the lobes of the perianth, they are opposite them, but if double or treble that number they are inserted into the base of the perianth; ovarium solitary; stigmas two, distinct; fruit indehiscent, two-celled, membranous, or somewhat coriaceous, compressed, sometimes expanded into a wing at the sides; seeds solitary in the cells, pendulous; albumen none; radicle pointing to the hilum; cotyledons flat, foliaceous. Trees and shrubs, with alternate, petiolate, simple leaves. Subtribe 1. *Ulmeæ*. Flowers loosely aggregate in small heads, pedicellate, hermaphrodite, or polygamous by abortion. Examples, *Ulmus*, *Planera*, *Celtis*, and *Sponia*. Subtribe 2. *Betuleæ*. Flowers in aments, each scale bearing one to three sessile flowers in its axil. Examples, *Betula*, *Alnus*, *Ostrya*. Tribe 2. *Salicineæ*. Flowers dioecious, disposed in aments, one in the axil of each scale; male flowers disposed in cylindrical catkins, each with a small gland-like perianth, and from two to thirty stamens, which are subadnate to the gland, generally distinct, rarely monadelphous. Female flowers disposed in



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dense, ovate, or cylindrical catkins, each with a free, simple perianth, which is often persistent or very small; ovarium one-celled; style one; stigmas two, often bifid; capsule one-celled, two-valved, cells many-seeded; seeds small, pendulous, covered with down all over, or only at the apex; albumen none; embryo straight; radicle pointing to the umbilicus; cotyledons flat, foliaceous. Trees and shrubs with alternate leaves; stipulas foliaceous, but sometimes small or even wanting. Examples, *Salix* and *Populus*. Tribe 3. *Quercineæ*, or *Cupuliferæ*. Flowers monoecious; male ones disposed in cylindrical catkins; perianth small, and scale-formed; the filaments usually free to the base: female flowers; involucrum various, one or many-flowered; perianth many-toothed, adhering to the ovarium; ovarium one or many-celled, containing many ovula; styles two or three, or multifid; stigmas distinct; involucrum after flowering becoming enlarged, and enclosing in part or altogether the pericarps, which are either solitary or many together; acorns or nuts one-celled, one-seeded by abortion; seed pendulous; albumen none; embryo straight; radicle pointing to the umbilicus; cotyledons thick or foliaceous. Trees with alternate leaves and deciduous stipulas. Examples, *Quercus, Corylus, Fagus, Castanea, Carpinus*. Tribe 4. *Plataneæ*. Flowers monoecious, collected into globose or oblong catkins of different sexes; involucrum at the base of the catkin four-leaved, or wanting: male flower; perianth of numerous small linear pieces intermixed with the stamens: female flower; scales absent or intermixed with the flowers; perianth adherent to the ovarium, which is either cup-shaped, or ending in small pilose bristles; carpels one to two, one-celled, united with the perianth, oblong or subturbinate, horned at the apex, dehiscent or indehiscent, rather coriaceous; seed solitary in each cell, pendulous; albumen none; embryo straight; radicle superior; cotyledons flat, foliaceous. Trees, with alternate, palmately lobed, stipulaceous leaves; buds hidden within the bases of the petioles. Examples, *Platanus, Liquidambar*. Tribe 5. *Myriceæ*. Flowers monoecious or dioecious, rarely hermaphrodite, disposed in unisexual catkins; scales ovate, each with a single flower in its axil: male flowers; perianth of two opposite scale-formed pieces; stamens four, free, one of which is often incomplete; anthers two-celled: female flowers; perianth becoming enlarged after flowering, each composed of three to six very small scales; ovarium simple, free; stigmas two, filiform; drupe sessile, globose, covered more or less on the outside by small grains of wax; ripe fruit dryish, terminated by the persistant style or blunt at apex; nut bony, valveless; albumen none, or fleshy; embryo straight, inverted; radicle superior; cotyledons fleshy, plano-convex. Aromatic shrubs full of resinous glands; leaves alternate, simple. Examples, *Myrica, Comptonia*.

226. *Gneteæ*, Blume.—Flowers monoecious or dioecious, disposed in aments or heads, which are involucrated by opposite, decussate, connate scales: male flower; perianth one-leaved, transversely cleft at apex; filaments branched, one or many anthered; cells of anthers separate or variously combined, each cell dehiscing by a pore at apex: female perianth constantly composed of two large or small connate scales, which gird one or two flowers; ovarium perforated at apex, one-celled; ovulum solitary, erect, terminated by a style-formed process, which is produced from the membrana of the nucleus; fruit indehiscent, drupaceous; pericarp coriaceous, baccate outside, but testaceous and fibrous inside; spermaderm formed from a membrana which is duplicate above and simple at the base; albumen fleshy; embryo central; radicle superior. Composed of much branched shrubs or trees, or sarmentose shrubs; branches nodosely articulated, opposite or fascicled; leaves opposite, entire, or quite entire, feather-nerved, sometimes very minute, or scale-formed, or wanting. Examples, *Gnetum, Ephedra, Casuarina*.

227. *Empetreæ*, Nuttall.—Flowers dioecious; perianth free, composed of imbricate scales, which are disposed in two series; stamens equal in number to the inner series of scales, and alternating with them; anthers roundish, of two distinct cells; ovarium free, seated on a fleshy disk, three, six, or nine-celled; ovula solitary, ascending; style one; stigma radiating, with as many rays as there are cells in the ovarium; fruit fleshy, surrounded by the persistent perianth, of three to nine bony cells; seeds solitary: embryo terete in the centre of the albumen; radicle inferior. Evergreen undershrubs, with narrow, exstipulate, alternate, or subverticillate leaves; habit of *Erica*. Examples, *Empetrum, Ceratiola, Corema*.

Fifth division. *Diclines-Gymnospermæ*. Jussieu.—Flowers unisexual or without a perianth; seeds naked.

228. *Coniferæ*, Jussieu.—Flowers monoecious or dioecious; male flowers collected into a catkin, all over a common rachis; consisting each of one or many monadelphous stamens; anthers two or many-lobed, dehiscing outwardly, often terminated by a crest, which is an uncovered portion of the scale out of which each stamen is formed: female flowers seldom solitary, but usually in cones; ovarium none, or spread open, and resembling a flat scale, destitute of either style or stigma, rising from the axil of a membranous bractea; ovula exposed; those in the cones in pairs on the face of the ovarium, inverted; those in the solitary flowers erect; fruit a solitary, naked seed or a cone; seed covered by a hard, crustaceous testa; albumen oily; embryo in the axis; radicle at the apex of the seed, having an organic connection with the albumen; cotyledons two, generally many-parted. Composed of trees and shrubs abounding in resin; leaves with parallel veins, usually acerose and persistent, and often spirally disposed. The wood of this order is of great importance, and also its resinous productions, as the different kinds of pitch, turpentine, and balsam. The seeds of *Araucaria* and one species of *Pinus* are eatable when roasted, and the berries of Juniper are diuretic. Tribe 1. *Taxineæ*. Floral buds one, rarely two-flowered, consisting of numerous scales which are imbricated and cruciately opposite; female flower solitary, naked; drupe succulent. Examples, *Taxus, Podocarpus, Schubertia*. Tribe 2. *Cupressineæ*. Female catkins consisting of a few scales which change into sub-globose cones or spurious berries; flowers erect, the stigma being directed upwards. Examples, *Juniperus, Thuja, Cupressus, Dacrydium, Callitris*. Tribe 3. *Abietineæ*. Female catkin consisting of numerous scales which imbricate and form a cone. Flowers inverted, the bracteas being adnate nearly their whole length, and the stigma directed downwards. Examples, *Pinus, Abies, Larix, Cedrus, Araucaria, Dammara, Cunninghamia*.

229. *Cycadeæ*, Persoon.—Flowers naked, dioecious, amentaceous: male flowers with two to five stamens

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which are crowded on the back of the scales of the ament; anthers sessile, one-celled, dehiscing inwards: female flowers either collected into a cone or surrounding the central bud in the form of contracted leaves or scales; ovaria distinct, adnate at their bases, one-seeded; styles very short, at length pervious; stigmas undivided; drupe containing a bony putamen; albumen fleshy and solid, conforming to the nut, which is dotted at top; embryo inverted, with a long funicle resembling a root; cotyledons connate at top; plumule squamulose, conspicuous before germination. Composed of shrubs or trees with the habit of Palms. Leaves pinnate, the young ones having the pinnæ spirally involute and expanding in the manner of Ferns. Aments or cones terminal, solitary, or twin; caudex becoming proliferous after florescence. The fecula in the trunk of *Cycas* is manufactured into a kind of Sago. Examples, *Cycas, Zamia, Encephalartus.*

Second class. *Monocotyledones*, or *Endogenæ*. De Candolle.—Embryo with one or many alternate cotyledons; stem composed of one simple, cellular envelope outside, and abundant cellular tissue inside, and fibres which are not disposed by layers, nor parallel, but cross each other in such a manner that, at the top of the plant, they are in the centre, while towards its base the same fibres are found in the circumference. In the woody species the outside of the stem is much harder than the centre, in others the stem is fleshy and hidden under ground, as rhizoma and the centre of bulbs; roots usually adventive, and destitute of lenticels. The leaves are generally alternate, sheathing, persistent, without stipulas, reduced to the petioles, or furnished with limbs in which the nerves are usually curved at the base.

First division. *Monoepigynæ*, Jussieu. — Stamens apigynous.

230. *Hydrocarideæ*, Jussieu.—Flowers spathaceous, hermaphrodite, or unisexual; perianth six-parted, of which the three outer ones are green, and the three inner white and petaloid; stamens definite or indefinite; ovarium adherent, one or many-celled; ovula numerous; stigmas three or six; fruit dry or fleshy, indehiscent, of one or more cells; albumen none; embryo straight, inverted. Composed of aquatic herbs. Leaves sometimes spiny; the nerves always parallel. The twisted peduncles and the manner of fertilization in *Vallisneria* is very singular. Examples, *Hydrocharis, Stratiotes, Vallisneria.*

231. *Balanophoreæ*, Richard. — Flowers unisexual, disposed in dense heads; the rachis or receptacle covered with scales or bristles, and sometimes here and there with thick peltate scales; seldom naked: male flowers pedicellate; perianth tripartite, equal, spreading, or in place of it a thick, truncate, obconical scale; stamens one or three; filaments united; anthers connate, bursting lengthwise: female flowers; ovarium cohering with the perianth and crowned by its limb, one-celled; ovule solitary, pendulous; style solitary, rarely twin, filiform; stigma simple, slightly convex; achenium roundish, crowned by the remains of the limb of the perianth; embryo minute, enclosed in a hollow on the surface of a cellular fleshy albumen. Composed of fungous-like, parasitical plants with naked stems, which are covered with imbricated scales. From habit this order is nearly allied to *Cytineæ*, but Richard has considered it more closely allied to *Hydrocharideæ*. Examples, *Balanophora, Helosis, Cynomorium.*

232. *Orchideæ*, Jussieu.—Perianth with a six-parted, ringent limb; the three outer segments equal, the three inner ones unequal, two of these last become uppermost by a twisting of the pedicel, the lower one or labellum is usually lobed, or developed in various odd shapes, with or without a spur at its base; three stamens are combined into a column, the two lateral of which are generally sterile, and the central one perfect, or exactly the contrary; anthers of two, four, or eight lobes; pollen powdery or in masses; ovarium one-celled, with three parietal placentas; style combined or joined with the column of stamens; capsule adherent to the perianth, three-valved, seldom fleshy; seeds indefinite, minute; albumen none; embryo solid, fleshy, undivided. Composed of terrestrial or epiphytical herbs; leaves sheathing, entire; bulbs tuberous, mixed with true roots, and containing a large portion of nourishment for the plants. Flowers of all singular, and of the greater number very beautiful. The nutritive substance called Salep is obtained from the roots of *Orchis, Mascula*, and others; and the Vanilla used for scenting Chocolate is the fruit of *Vanilla aromatica*, a native of the West Indies. The order is divided into the following tribes. Tribe 1. *Neottieæ*. Anther parallel with the stigma, and erect; pollen simple, or consisting of granules in a loose state of cohesion. Examples, *Goodyera, Spiranthes, Neottia, Ponthieva, Prasophyllum, Listera.* Tribe 2. *Arethuseæ*. Anther terminal, opercular; pollen as in *Neottieæ*. Examples, *Arethusa, Pogonia, Epipactis, Corallorrhiza.* Tribe 3. *Gastrodieæ*. Anther terminal, opercular; pollen cohering in granules, which finally become waxy and are indefinite in number. Examples, *Gastrodia, Vanilla, Prescotia.* Tribe 4. *Ophrydeæ*. Anther terminal, erect, or inverted; pollen as in *Gastrodieæ;* pollen masses with a caudicula. Examples, *Orchis, Ophrys, Serapias, Habenaria, Bonatea.* Tribe 5. *Vandeæ*. Pollen cohering in grains, which become waxy and are definite in number; the masses attached to the stigma by a transparent caudicula or gland. Examples, *Oncidium, Brassia, Vanda, Renanthera, Cyrtopodium, Eulophia, Catasetum.* Tribe 6. *Epidendreæ*. Pollen as in *Vandeæ*, the masses attached to the stigma by filiform, powdery, reflexed caudicula. Examples, *Bletia, Epidendrum, Cattleya.* Tribe 7. *Malaxideæ*. Pollen as in *Vandeæ;* the masses loose, sometimes cohering at the apex by viscid, powdery, or granular matter. Examples, *Dendrobium, Malaxis, Calypso, Liparis, Stelis.* Tribe 8. *Cypripedieæ*. Lateral anthers fertile, the middle sterile and petaloid. Example, *Cypripedium.*

233. *Apostaceæ*, Blume.—Perianth six-cleft, regular, or nearly so, deciduous, in two verticils; stamens three, adnate to the base of the style, two of them opposite the lateral inner segments of the perianth, and the third opposite the front outer segment, which is sometimes wanting or destitute of an anther; anthers oblong, two-celled, fixed by their back, dehiscing inwardly; pollen composed of simple loose granules; style free at top, and terminated by a blunt, trigonal, or slightly three-lobed stigma; ovarium adherent; placentas central, many-ovulate; capsule three-celled, three-valved; valves septiferous in the middle, cohering at the base and apex; seeds very numerous, minute, ovate, having the testa conforming to the nucleus, or scobiform, with a membranous loose testa. Composed of rhizocarpous plants with fibrous roots; stems simple, or simply branched; leaves simple, undivided, entire, with converging nerves sheathing at their bases; flowers racemose, unibracteate,



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yellowish. The order borders close upon *Orchideæ*, of which it is probably only a tribe. Examples, *Apostasia*, *Neuwiedia*.

234. *Scitamineæ*, R. Brown.—Perianth double, outer verticil (calyx) of three lobes; inner verticil (corolla) of three nearly equal pieces, or one of the lobes is irregular; the third verticil (transformed stamens) of three parts, of which the two lateral parts are sometimes abortive, and the central one analogous to the labellum or lip in *Orchideæ*; it is often three-lobed, and is remarkable for its size and form. There are three stamens, the two lateral ones of which are sterile, and the middle one fertile and placed opposite the labellum: its filament usually prolonged beyond the anther in the form of an appendage, which is either entire or lobed; anther two-celled; ovarium three-celled; style filiform; stigma dilated; fruit dry or fleshy, with a loculicidal dehiscence, three-celled; seeds indefinite; albumen mealy; embryo contained in a membrane called a vitellus. Composed of herbs with rhizomatose roots; leaves sheathing, with a simple midrib, and diverging feathered veins; flowers terminal, surrounded by sheathing bracteas. The roots or rhizoma are aromatic, and yield the Ginger, Zedoary, Galingall. The seeds of others have the same qualities as Cardamoms. The roots of Turmeric afford a well known yellow dye. Examples, *Zinziber*, *Roscoea*, *Amomum*, *Costus*, *Hedychium*.

235. *Canneæ*, R. Brown.—This order is often united with the preceding, from which it principally differs in the fertile stamen bearing a one-celled anther, which is placed laterally in relation to the labellum or lip of the flower, as well as in the embryo being destitute of the envelope or vitellus. Composed of herbs similar to *Scitamineæ*. Arrow Root is the fæcula of the rhizoma of *Maranta arundinacea*. Examples, *Canna*, *Maranta*.

236. *Musaceæ*, Jussieu.—Perianth six-parted, petaloid, disposed in two verticils, more or less irregular; stamens six, inserted in the middle of the lobes of the perianth, some of which are always abortive; ovarium adherent, three-celled; style simple; stigma three-lobed; fruit three-celled, with a loculicidal dehiscence, or fleshy and indehiscent; seeds three to many, sometimes furnished with hairs near the hilum; embryo in the centre of a mealy albumen; leaves generally having the lateral nerves of the limb parallel, mutually sheathing at their bases and forming a spurious stem; flowers terminal, with spathaceous bracteas. The nutritive tropical fruits called Banana and Plantain are the produce of *Musa*, the leaves of which are also used as thatch. The petioles of *Musa textilis* afford fibre, from which the delicate muslin of India is prepared. Example, *Musa*, *Strelitzia*, *Heliconia*, *Urania*.

237. *Irideæ*, Jussieu.—Perianth six-lobed, usually irregular; stamens three, opposite the outer lobes of the perianth; ovarium adherent, three-celled; stigmas three, simple, or membranous and petaloid; capsule three-celled, three-valved, with a loculicidal dehiscence; seeds indefinite; albumen fleshy or corneous; embryo cylindrical; radicle pointing to the hilum. Composed of herbs with fleshy rhizomatose roots; leaves or petioles generally sheathing, ensiform, equitant, in two rows, except in Crocus, with parallel nerves; spatha generally scarious; the rhizoma are stimulating, as in the Oris-root of the shops, which is obtained from *Iris florentina*; those of *Iris versicolor* are purgative. The stigmas of *Crocus sativus* are the true Saffron. All the plants of this order are extremely ornamental, and are therefore universal favourites. Examples, *Iris*, *Marica*, *Sisyrinchium*, *Tigridia*, *Watsonia*, *Crocus*, *Ixia*, *Gladiolus*.



238. *Burmanniaceæ*, Blume.—Perianth tubular, coloured, six cleft, the three outer keeled, the three inner minute; stamens three, inserted in the tube of the perianth opposite the inner segments, and sometimes alternating with three sterile filaments; anthers sessile, two-celled, dehiscing transversely; connective fleshy; ovarium adherent, three-celled; cells many-seeded; dissepiments alternating with the wings or keels of the perianth; style solitary, crowned by three dilated stigmas; capsule crowned by the withered perianth; three-celled, three-valved, opening irregularly; seeds minute. This order consists of tufted herbs with radical, equitant, acute leaves, and slender scapes, which are terminated by sessile flowers. The order is said to be nearly related to *Restiaceæ*, particularly to the genus *Xyris*. Examples, *Burmannia*, *Conyanthes*, *Gynosiphon*, *Sasum*.

239. *Hæmodoraceæ*, R. Brown.—Perianth petaloid, with a regular six-parted tube; stamens three, opposite the inner lobes of the perianth, or six or more, polyadelphous; anthers bursting inwardly; ovarium adherent; stigma undivided; fruit capsular, three-valved, indehiscent; seeds definite, peltate, or indefinite; albumen farinaceous; embryo minute. Composed of small ornamental shrubs or herbs with sheathing, equitant, linear, or lanceolate leaves. The roots of several plants of this order yield an abundance of crimson dye, particularly that of *Dilatris tinctoria* of North America. Examples, *Hæmodorum*, *Anigozanthos*, *Conostylis*.

240. *Amaryllideæ*, R. Brown.—Perianth of six petaluid lobes in two verticils; stamens six, inserted in the perianth; besides there are often traces of floral verticils not developed adhering to the perianth; anthers bursting inwardly; ovarium adherent; stigma three-parted; capsule three-celled, with a loculicidal dehiscence, or baccate; seeds indefinite; albumen fleshy; embryo almost straight. Composed of bulbous-rooted ornamental plants; leaves linear or lanceolate, with parallel nerves; flowers furnished with spathaceous bracteas. The bulbs of *Hæmanthus toxicarius* are what the Hottentots poison their arrows with; those of *Narcissus poeticus* are emetic. Examples, *Amaryllis*, *Narcissus*, *Crinum*, *Pancratium*, *Galanthus*, *Leucojum*, *Doryanthes*, *Alströmeria*.

241. *Dioscoreæ*, R. Brown.—Flowers dioecious, rarely hermaphrodite; perianth six-parted: male flower with six stamens, inserted in the base of the lobes of the perianth; female flower with an adherent, three-celled ovarium, a trifid style, and a foliaceous, compressed, usually one-celled fruit; seeds flat, embryo small, placed in a cavity near the hilum; albumen cartilaginous. Composed of climbing or twining shrubs or herbs, with tuberous roots, alternate or opposite leaves, which have the nerves reticulate. Flowers small, bracteate, terminal, often panicled or spiked. The roots of *Dioscorea sativa* and other species are the Yams of the Tropics, a well-known food. The order agrees with *Smilaceæ* in the reticulately nerved leaves, and is divided into the following tribes. Tribe 1. *Dioscoreæ*. Style trifid; stigmas undivided; fruit a thin, compressed capsule, usually three-celled, but having two of the cells generally abortive; seeds flat; embryo small in the

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cavity of the albumen near the hilum. Examples, *Dioscorea*, *Rajania*, *Testudinaria*. Tribe 2. *Tameæ*, Gray. Style one; stigmas three; fruit fleshy, three-celled, indehiscent; seeds ovate; embryo minute, lying at the extremity remote from the hilum. Flowers small, axillary, racemose. The roots are purgative and dangerous. Example, *Tamus*.

242. *Hypoxideæ*, R. Brown.—Perianth regular, six-parted; stamens six, inserted at the base of the lobes of the ovarium, adherent, three-celled; stigma three-lobed; fruit indehiscent, sometimes fleshy; seeds numerous; embryo in the centre of a fleshy albumen, without any precise direction. Composed of herbs with fibrous roots, stiff, plicate leaves, and yellow or white starry flowers. Allied to *Hæmodoraceæ*. Example *Hypoxis*.

243. *Barbacenieæ*, Arnott.—Perianth six-parted, petaloid, regular, in two verticils; stamens six, or in six fascicles, rarely in three, inserted into the bases of the segments of the perianth; anthers bursting inwardly; disk fleshy, epigynous; ovarium adherent; style one; crowned by a three-lobed stigma; capsule three-celled, three-valved; seeds indefinite, cuneiform; testa coriaceous, furrowed; hilum prominent. Composed of elegant shrubby, simple or branched plants, natives of South America, having some of the habit of small species of *Yucca* or *Pandanus*. This order is said to hold an intermediate station between *Hypoxideæ* and *Bromeliaceæ*. Examples, *Barbacenia*, *Vellosia*, *Xerophyta*.

Second division. *Monoperigynæ*, Jussieu. Stamens perigynous.

244. *Smilaceæ*, R. Brown.—Flowers hermaphrodite, monoecious, or dioecious; perianth regular, six-parted, but often from four to eight-parted; stamens equal in number to the segments of the perianth; ovarium free; styles one, four, or five; stigmas three or four; fruit either a spherical capsule or berry, three to four-celled, or only one-celled by abortion; seed one to three in each cell; testa membranous; albumen horny or fleshy; embryo usually remote from the hilum. Composed of herbs or shrubs, often climbing. Leaves with the veins sometimes reticulated as in dicotyledonous plants; sometimes verticillate. In *Ruscus* the leaves are furnished with a kind of stipulas in the centre. The roots and stems are diuretic, as the Sarsaparilla. The roots of *Trillium* are emetic. Examples, *Trillium*, *Smilax*, *Paris*, *Convallaria*, *Streptopus*, *Ruscus*.

245. *Asphodeleæ*, R. Brown.—Perianth petaloid, six-parted, persistent, regular; stamens six, usually joined at their bases more or less, and with the lobes of the perianth, or hypogynous, the alternate ones dissimilar; anthers bursting inwards; ovarium free, triangular, three-celled; stigmas three, or only one, which is triangular; capsule three-celled, three-valved, with a loculicidal dehiscence; valves septiferous in the middle; seeds solitary or twin in each cell, or numerous, when the latter is the case they are arranged in two rows; testa black, brittle, crustaceous; albumen fleshy; embryo enclosed. Composed of herbs and shrubs, or bulbous-rooted plants. Leaves usually ensiform with parallel veins. Peduncles articulated. The roots and leaves of several of the plants of this order are purgative, as the Aloes. Gum Dragon is yielded by *Dracæna draco*. The Onion, Leek, Garlic, Chives, &c., belong to the genus *Allium*. All the species yield a gummy, viscid juice, which contains a bitter, stimulant principle. The order is separated into two tribes. Tribe 1. *Asparageæ*. Perianth six-parted. Examples, *Asparagus*, *Asphodelus*, *Scilla*, *Aloe*, *Ornithogalum*, *Hyacinthus*, *Lachenalia*, *Anthericum*, *Dianella*. Tribe 2. *Gilliesieæ*. Perianth six-parted, or by the cohesion of the two outer front segments five-parted; æstivation twisted; stamens in a double row; outer series forming either a six-toothed urceolus or three scale-like bodies, of which the front one is very unlike the others; inner one of six fertile stamens, or a six-toothed urceolus, of which the three anterior teeth alone bear anthers. Plants with tunicated bulbs and grassy leaves. Flowers umbellate, rising from spathaceous bracteas. Examples, *Miersia*, *Gilliesia*.



246. *Bromeliaceæ*, Jussieu.—Perianth tubular, six-cleft, the outer three persistent, the inner three petaloid, marcescent, or deciduous; stamens six, seldom more, inserted in the bases of the segments of the perianth; ovarium free or cohering more or less; style one; stigma three-parted, often twisted; fruit capsular or succulent, three-celled; seeds indefinite; embryo cylindrical, recurved, basilar; albumen farinaceous. Composed of almost stemless plants. Leaves stiff, channelled, usually spiny-toothed on the margins. Sometimes, as in the *Bromelia*, the fruits of the same spike grow together into a mass by means of the perianths becoming succulent, and is what forms the Pine-Apple, each teat of which is a separate fruit. The *Agave Americana*, or American Aloe, is also of this family, noted for the quick growth of its tall flower stem. The inside of the scapes or stems makes good razor strops, on account of containing a small portion of silica. Cordage is made out of the fibres of the leaves of some species. The juice of the American Aloe is used in Mexico as the refreshing drink under the name of Pulco. Example, *Bromelia Agave*.

247. *Liliaceæ*, Jussieu.—Perianth regular, six-parted; stamens six, opposite the segments of the perianth, and inserted in their bases; ovarium free; style one; stigma simple, or three-lobed; capsule three-celled, three-valved, with a loculicidal dehiscence; seeds numerous, generally flat, packed one above the other in one or two ranks; testa spongy, dilated, or winged; albumen fleshy; embryo straight; radicle next the hilum. Composed of plants with scaly bulbs, or woody stems. Leaves with parallel veins. The roots of some species of *Lilium* are cooked and eaten like potatoes in Eastern Siberia. The order is divided into two principal tribes. Tribe 1. *Tulipeæ*. Perianth deeply divided. Examples, *Lilium*, *Fritillaria*, *Erythronium*, *Tulipa*, *Yucca*, *Gloriosa*, *Calochortis*. Tribe 2. *Hemerocallideæ*. Perianth tubular. Examples, *Hemerocallis*, *Polyanthes*, *Agapanthus*, *Blandfordia*, *Veltheimia*, *Aletris*, *Tulbaghia*, *Brodiea*.

248. *Pontederiaceæ*, Kunth.—Perianth tubular, coloured, six-parted, more or less irregular, with a circinal æstivation; stamens three or six, unequal; ovarium free, or very little adherent, three-celled; stigma simple; capsule with a loculicidal dehiscence; seed indefinite; testa membranous; albumen farinaceous; embryo straight, with the radicle next the hilum. Composed of aquatic or marsh plants. Leaves sheathing at their bases, with parallel nerves. Flowers usually blue, surrounded by spatha. Examples, *Pontederia*, *Heteranthera*, *Leptanthus*.

249. *Wachendorfiaceæ*, Batch.—Perianth coloured, six-parted, irregular; stamens three, inserted in the bases

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of the three inner segments of the perianth; anthers dehiscing inwardly; ovarium free; ovula solitary, or numerous in the cells; style one; stigma undivided; fruit capsular, three-celled, three-valved; seeds roundish; albumen farinaceous; embryo minute; the radicle next the hilum. Herbs with bulbous roots and equitant leaves. Examples, *Wachendorfia*, *Xyphidium*.

250. *Melanthaceæ*, Batch.—Perianth coloured, regular, six-parted, the margins of the segments usually involute in æstivation; stamens six, inserted into the segments of the perianth; anthers bursting outwardly; ovaria free, three, or combined into a three-celled fruit; style trifid; stigmas three, undivided. Fruit composed of eight free carpels, which open each by the ventral suture, or of three carpels which separate at maturity; seeds numerous, with a membranous testa; albumen fleshy. Composed of herbs with bulbous or fleshy, rhizomatose roots; sheathing leaves, with parallel nerves. Nearly allied to *Liliaceæ*. The stems and bulbs generally are cathartic, diuretic, and emetic. Colchicum is poisonous, but is employed in small doses in the cure of the gout. The root of *Veratrum* is sternutatory, irritating, emetic, and poisonous. Every plant of the order is suspicious. Examples, *Colchicum*, *Uvularia*, *Melanthium*, *Tofieldia*, *Helonias*, *Veratrum*, *Peliosanthes*, &c.

251. *Junceæ*, Jussieu.—Perianth regular, of a glumaceous nature, composed of two verticils of three parts each; stamens usually six, seldom three, opposite the lobes of the perianth, and when the latter number opposite the exterior lobes; ovarium free; style one; stigmas three, filiform, or only one and three-lobed; capsule three-celled, many-seeded, with septiferous valves, and a loculicidal dehiscence; or only one-celled and one-seeded, indehiscent, the seed situated at the base of the capsule; albumen fleshy; embryo near the hilum. Composed of grassy or rushy herbs; leaves terete, channelled or flat, with parallel veins. Examples, *Juncus*, *Luzula*, *Flagellaria*, *Xerotes*, *Narthecium*.

252. *Restiaceæ*, R. Brown.—Perianth two or six-parted; stamens two to six, or equal in number to the lobes of the perianth, but when half that number they are opposite the inner lobes; anthers one-celled; ovarium one, or many-celled; ovulum one in each cell, pendulous; albumen mealy; embryo at that extremity of the seed the most remote from the hilum. Composed of herbs or subshrubs analogous to those of *Junceæ*. Leaves narrow or wanting; culms naked or sheathed; flowers in spikes or heads, separated by scales. The order is separated into two tribes. Tribe 1. *Restieæ*. Perianth two or six-parted, seldom wanting; stamens one to six, perigynous; ovarium one or more celled; seeds solitary in the cells. Examples, *Restio*, *Elegia*, *Centrolepis*, *Eriocaulon*. Tribe 2. *Xyrideæ*. Perianth six-parted; outer three glumaceous, inner three petaloid, unguiculate; stamens six, three fertile, inserted upon the apices of the claws of the three inner segments of the perianth; ovarium many-ovulate; style trifid; stigmas multifid or undivided; capsule one-celled, three-valved, many-seeded; culms naked; flowers in heads. Examples, *Xyris*, *Abolboda*.

253. *Palmæ*, Jussieu.—Flowers hermaphrodite or polygamous; perianth persistent, composed of two verticils of three parts each; stamens six from the base of the perianth, rarely three; ovarium three-celled, or deeply three-lobed, with one ovulum in each cell or lobe; berry or drupe composed of fibry tissue; albumen cartilaginous, with a central or lateral cavity, or ruminated; embryo lateral at the side, opposite the empty cavity of the albumen, cylindrical, flat, or circular; cotyledons very thick in germination. Composed of trees, with generally simple trunks; leaves with persistent, scaly bases, and feather-nerves, and usually divided limbs, the lobes adhering in the young state; spadix branched, enclosed in a sheath of one or more valves. The wood of the Cocoa-nut tree is used for many purposes on account of its durability. The terminal buds of the Cabbage tree are boiled and eaten as a vegetable. The fermented juice of the Guinea Palm is very refreshing, and is called Palm wine. The leaves of most species are used for thatch. The albumen and milk of the Cocoa-nut, and of several other species, are eaten; the fibres of the fruit is used to make ropes as well as mattresses. By expressing the nuts of the Guinea Palm an oil is obtained which is used in food and for lamps, and even for making candles, under the name of Palm oil. The Date is the fruit of *Phœnix dactylifera*, and the Sago is made from the trunk of *Phœnix farinifera*. The Betel Nut, well known for its narcotic and exhilarating qualities, is the fruit of *Areca catechu*. The *Ceroxylon andicola* exudes a waxy substance from the axils of the leaves. The *Calamus draco* yields the best kind of Dragon's Blood. The order is separated into the following tribes by Dr. Martius. Tribe 1. *Sabalinæ*. Spaths many, incomplete; ovarium three-celled; berry or drupe one to three-seeded; fronds pinnate, or palmately fan-shaped. Examples, *Sabal*, *Chamædorea*, *Thrinax*. Tribe 2. *Coryphinæ*. Spaths numerous, incomplete; pistils three, cohering inside, usually solitary at maturity; berry or drupe one-seeded; fronds pinnate, or palmately fan-shaped. Examples, *Moreraia*, *Raphis*, *Corypha*, *Phœnix*. Tribe 3. *Lepidocaryæ*. Spaths numerous, incomplete; flowers in aments; ovarium three-celled; berry one-seeded, tessellately corticate; fronds pinnate, or palmately fan-shaped. Examples, *Mauritia*, *Calamus*, *Sagus*. Tribe 4. *Borasseæ*. Spaths many, incomplete; flowers in aments; ovarium three-celled; berry or drupe three-seeded; fronds palmately fan-shaped. Examples, *Borassus*, *Lodoicea*, *Hyphæne*. Tribe 5. *Arecinæ*. Spaths wanting, or one or more, complete; ovarium three-celled; berry one-seeded; fronds pinnate or bipinnate. Examples, *Areca*, *Euterpe*, *Seaforthia*, *Caryota*. Tribe 6. *Cocoinæ*. Spaths one or more, complete; ovarium three-celled; drupe one or three-seeded; fronds entire or pinnate. Examples, *Syagrus*, *Elate*, *Cocos*, *Bactris*, *Manicaria*, *Elæis*.

Third division. *Monohypogynæ*, Jussieu.—Stamens hypogynous.

254. *Commelineæ*, R. Brown.—Perianth six-parted, of which the three outer segments are foliaceous, and the three inner ones are petaloid; they are either free, or cohere at their bases; stamens three or six; ovarium three-celled; style and stigma undivided; capsule two or three-celled, two or three-valved; valves septiferous; seeds usually twin in the cells; embryo inverted, flat or circular in a cavity, at that end of the seed most remote from the hilum; albumen fleshy. Composed of herbs. Leaves usually sheathing at their bases with parallel nerves; radicle projected from the centre of the embryo. Examples, *Commelina*, *Tradescantia*, *Anelema*, *Dichorizandra*.

255. *Butomeæ*, Richard.—Perianth regular, six-parted, of which the three outer ones are green, and the three inner ones are petaloid; stamens definite or inde-

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finite; ovaria three, six, or more, free or joined; follicles distinct or joined, many-seeded; seeds very small; albumen none; embryo straight or curved; radicle next the hilum. Composed of elegant aquatic plants. Leaves with parallel veins; flowers umbellate, red, white, or yellow. Examples, *Butomus*, *Limnocharis*.

256. *Alismaceæ*, R. Brown.—Perianth and stamens the same as in *Butomeæ*; ovarium of several one-celled, separate carpels; ovula solitary, or in distant pairs; styles and stigmas several; fruit of numerous dry indehiscent carpels; albumen none; embryo cylindrical, curved; radicle next the hilum. Composed of aquatic or bog plants; leaves with parallel nerves; flowers panicled. Examples, *Alisma*, *Sagittaria*, *Actinocarpus*.

257. *Juncagineæ*, Richard.—Perianth green, rarely wanting, six-parted; stamens six; ovarium composed of three or six combined carpels; fruit dry, three or six-celled; seeds one or two in each cell or carpel, erect, approximate at their bases; albumen wanting; embryo straight, radicle at that end of the seed most remote from the hilum; plumule emitted through a lateral cleft of the embryo. Composed of herbs natives of bogs and marshes; leaves ensiform, with parallel veins; flowers small, green, disposed in spikes or racemes. Examples, *Triglochin*, *Scheuchzeria*.

258. *Pandaneæ*, R. Brown.—Flowers dioecious or polygamous, without any perianth, covering the spadix: male flower composed of a single two-celled stamen; female flower formed of close but distinct ovaria, each ovarium crowned by a stigma; ovulum solitary, erect; drupes fibry, one-seeded, or berries composed of numerous many-seeded cells; albumen fleshy; radicle pointing to the hilum. Composed of remarkable branched trees, throwing out roots from the stems at a considerable distance above the soil. The branches are in whorls. The leaves are disposed in a spiral manner, linear-lanceolate, sheathing, usually spiny on the edges and keel, with parallel nerves. The fruit and seeds of several species of *Pandanus* are eatable; the fruit resembles the Pine-Apple both in shape and smell. Examples, *Pandanus*, *Freycenetia*.

259. *Typhaceæ*, De Candolle.—Flowers unisexual, arranged upon a naked spadix; perianth of three or more parts, not petaloid, but glumaceous: male flower with three or six stamens; female flower composed of a free, one-celled ovarium, containing a solitary, pendent ovulum, a short style, and one or two linear stigmas; fruit dry, indehiscent, one-seeded; embryo straight, cylindrical in the centre of a farinaceous albumen; radicle next the hilum, cotyledons cylindrical. Composed of grass-like herbs, natives of marshes, pools, lakes, ditches, and rivers; leaves stiff, ensiform, sheathing with parallel nerves. Examples, *Typha*, *Sparganum*.

260. *Aroideæ*, Jussieu.—Flowers unisexual upon a common spadix, surrounded by a spath; perianth wanting, or composed of four or five pieces; stamens very short; anthers composed of one, two, or more extrorse cells; ovarium superior, of one to three cells; ovula numerous, hanging from the parietes of the fruit; fruit dry or fleshy, indehiscent; seeds one or more in each fruit; embryo straight, cylindrical, in the centre of a fleshy or farinaceous albumen; radicle obtuse, generally next the hilum; cotyledons cylindrical. Composed of herbs or shrubs, with underground or ascending stems, which throw out roots like the Ivy. The leaves are sheathing, simple, or compound, with parallel or diverging nerves. The plants of this order are acrid and dangerous; the *Caladium seguinum*, by chewing which persons lose the power of speech in consequence of the inflammation it occasions, and on that account it is called Dumb Cane in America. However, the leaves of some species of *Arum* are boiled and used as greens in tropical countries, and the roots of *Arum esculentum*, and some others, are boiled or roasted, and used instead of potatoes under the names cocoes or edoes. The fecula of the roots is analogous to Sago. This family is divided into the following tribes. Tribe 1. *Arineæ*. Flowers unisexual: perianth wanting. Examples, *Arum*, *Caladium*, *Calla*, *Richardia*. Tribe 2. *Orontiaceæ*. Flowers hermaphrodite; perianth present. Examples, *Dracontium*, *Houttynia*, *Pothos*, *Acorus*.



261. *Taccaceæ*, Kunth.—Perianth superior, six-parted, regular, persistent; stamens six; filaments inserted into the bases of the segments of the perianth, dilated, and cucullate at their apices; lobes of anthers separate, adnate to the inside of the hoods or cucullæ of the filaments, with loosened apices; ovarium one-celled, with three parietal, polyspermous placentas; style trisulcate; stigmas three, dilated; berry many-seeded; seeds striated, albuminous; embryo minute in the region of the umbilicus. Composed of glabrous herbs with tuberous roots. Leaves all radical, palmate, or bipinnatifid; scapes radical, undivided; umbel terminal, simple, surrounded by a many-leaved involucrum; peduncles intermixed with threads. Example, *Tacca*.

262. *Pistiaceæ*, Richard.—Flowers unisexual, enclosed in the same spath; stamens two to seven in a spath; ovarium one in each spath, one-celled; ovula several, erect, or horizontal; style short; stigma simple; fruit membranous, one-celled, indehiscent; seed solitary, or several, with a thick, spongy testa; chalaza thick, adhering to the apex of the cotyledon, and separable from the integuments; embryo large in the axis of a thin, fleshy albumen, having a lateral cleft for the emission of the plumule, or minute at the extremity of a copious mealy albumen most remote from the hilum; radicle pointing to the hilum. Composed of singular floating plants; flowers rising from the margins of the stems. Examples, *Pistia*, *Lemna*.

263. *Potameæ*, Jussieu.—Flowers hermaphrodite or unisexual; perianth two or four-parted, often deciduous, and sometimes wanting; stamens definite; ovaria one or more, inserted on the receptacle or central spadix; style one, or none; stigma simple; capsules one-celled, one-seeded, indehiscent; seed inverted, pendulous; albumen none; embryo straight, with a lateral cleft for the emission of the plumule, or incurved; radicle large, pointing to the end opposite to the hilum. Composed of aquatic herbs with simple, generally alternate, leaves, furnished with parallel veins; flowers minute, generally disposed on a spadix. *Zostera* is used for mattresses under the name of *Ulva marina*. Examples, *Potamogeton*, *Zannichellia*, *Ruppia*, *Zostera*.

264. *Podostemeæ*, Richard.—Flowers naked, hermaphrodite, bursting through an irregularly lacerated spath; stamens definite or indefinite, monadelphous, the alternate ones sterile and shorter; ovarium free, spuriously two-celled; ovula numerous; styles two or wanting; placenta forming the dissepiment; fruit somewhat pedicellate, capsular, two-valved, septicidal, the valves falling off from the placenta; seeds indefinite, minute. Composed of branched, floating, aquatic herbs, with capillary, linear, irregularly lacerated, or minute,

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imbricated leaves, and very minute flowers. This family is more nearly allied to *Potameæ* than to any other. Examples, *Podostemum*, *Lacis*, *Mniopsis*.

265. *Cyperaceæ*.—Flowers glumaceous, hermaphrodite or unisexual, each furnished with a single one-valved bractea or scale called a gluma, which are imbricated on a common axis; stamens three, with capillary filaments, and acuminated, two-celled anthers, which are cordate at their bases. Sometimes there is an additional row of abortive filaments or setæ; ovarium free, one-celled; ovulum solitary, erect; stigmas two or three, united at their bases; achenia triangular, compressed; embryo small at the base of a farinaceous albumen. Composed of grassy herbs generally without joints, with fibrous or knotted roots; leaves with entire sheaths and linear limbs. The roots of *Cyperus esculentus* are eaten, those of *Cyperus longus* are bitter and tonic, and those of *Papyrus odoratus* are warm and tonic. The stems of *Papyrus antiquorum* are the Egyptian *Papyrus*, or paper. The rushes used for chair bottoms are the stems of several species of *Scirpus*. *Cyperaceæ* is divided into the following tribes by Kunth. Tribe 1. *Cypereæ*. Spikes generally many-flowered; scales distich, equal, lower ones usually empty; flowers hermaphrodite, without any perianth; style deciduous, equal; achenia never beaked. Examples, *Cyperus*, *Papyrus*, *Mariscus*, *Kyllingia*, *Remirea*. Tribe 2. *Scirpeæ*. Spikes generally many-flowered; scales imbricated on all sides, rarely distich, equal, a few of the lower ones often empty; flowers hermaphrodite; perianth wanting, or rudimentary; setæ or hairs six, rarely more, but never fewer, sometimes instead there are three scales intercepted by as many bristles; achenia usually mucronate or beaked by the persistent base of the style. Examples, *Eleocharis*, *Scirpus*, *Eriophorum*, *Isolepis*, *Fuirena*, *Fimbristylis*. Tribe 3. *Hypolytreæ*. Spikes many-flowered; scales imbricated on all sides, a few of the lower ones empty. Flowers hermaphrodite, each enclosed by from one to six proper, smaller, thinner, scales; perianth wanting; style bifid or trifid, equal, deciduous, or with a persistent beak-formed base. Example, *Hypolytrum*. Tribe 4. *Rhynchosporeæ*. Spikes generally few, flowered; scales distich, or imbricated on all sides, the lower ones empty; flowers usually polygamous; perianth none, or composed of six, rarely eight or ten, seldom more or less, valves; stamens three, seldom six; achenia beaked by the persistent base of the style. Examples, *Rhynchospora*, *Cladium*, *Chætospora*, *Schænus*. Tribe 5. *Sclerineæ*. Spikes monoecious or androgynous; perianth none; stamens generally three, rarely two or one; style trifid, equal at the base; achenia stony or crustaceous, often propped by a three-lobed disk, or a flat bipartible one. Example, *Scleria*. Tribe 6. *Caricineæ*. Flowers unisexual, spicate; male spikes simple; female ones more or less compound; scales imbricated on all sides; perianth none; style usually solitary. Examples, *Carex*, *Uncinia*, *Elyne*.

266. *Gramineæ*, Jussieu.—Flowers glumaceous, hermaphrodite, or unisexual, outer glume (*bractea*) of two pieces of the form of scarious valves, containing one or more flowers, (*locusta*.) The glumelle of each flower is formed of two unequal valves, (*paleæ*,) the lower or outer one simple, and the other composed of two joined pieces, which is evident from containing two principal nerves and two points; the glumellules or small scales are present, sometimes to the number of two or three between the glumelle and the base of the stamens, and are either free or united, when their number is two they alternate with the valves of the glumelle; stamens from one to six, but generally three; filaments very slender and elongated; anthers versatile; ovarium free; styles two; stigmas hairy; caryopsis or pericarp dry, adhering more or less to the seed; albumen farinaceous; embryo small, lenticular, external, placed on one side at the base of the albumen, with one large cotyledon and a developed plumule. This order consists of the true grasses; they are either annual or perennial plants; the roots of the latter are rhizomatose, from which the culms or stems rise yearly, and surrounded by sheathing leaves. The stems of the Bamboo are branched and permanent, and rise even to the height of fifty feet or more. The sheaths of the leaves are split on one side, and on the opposite side bear on the summit a membranous appendage called the ligula. The limbs of the leaves are linear or lanceolate, with parallel nerves, and are placed outside of the ligulæ; the flowers are panicled or in ears. This is the most useful family of vegetables on account of the farinaceous grain, as Wheat, Oats, and Barley, &c., and the green herbage. Rice is the produce of *Oryza sativa*, a plant cultivated to a great extent in all tropical countries. The Maize, or Indian Corn, cultivated in all temperate countries, is the produce of *Zea Mays*. The Sugar-cane, or *Saccharum officinarum*, is a plant the juice of which contains more saccharine matter than any other; although many grasses contain more or less abundance of sugar, as *Holcus saccha atus*, a plant cultivated for the purpose in Italy. The leaves of *Cymbopogon schœnanthus*, or Lemon Grass, is the plant from which the oil called *Ivarancusa* is obtained: *Anthoxanthum* and some other grasses exhale an aromatic odour. The epidermes of grasses contain a considerable quantity of silex: the grain of *Lolium temulentum*, or Darnel, has been reported inebriating, narcotic, and poisonous. The order has been divided into the following tribes by Kunth. Tribe 1. *Oryzeæ*. Spikelets sometimes one-flowered, having the glumes often abortive, sometimes two or three-flowered, one or two of the lower flowers unipaleate and neuter, and the terminal one fertile; paleæ chartaceously rigid; flowers generally unisexual, for the most part hexandrous. Examples, *Leersia*, *Oryza*, *Zizania*, *Pharus*. Tribe 2. *Phalarideæ*. Spikelets hermaphrodite or polygamous, rarely monoecious, sometimes one-flowered, with or without a septiform rudiment to the superior flower; sometimes two-flowered, both hermaphrodite or male; sometimes two or three-flowered, the terminal one fertile, the rest incomplete; glumes generally equal; paleæ generally spiny; styles and stigmas generally elongated. Examples, *Lygeum*, *Zea*, *Spartium*, *Cornucopia*, *Coix*, *Phalaris*, *Phleum*, *Alopecurus*, *Holcus*, *Anthoxanthum*. Tribe 3. *Paniceæ*. Spikelets two-flowered, the lower flower incomplete; glumes of a slighter texture than the paleæ, the lower one abortive, but rarely both; paleæ usually awnless, the lower one concave; caryopsis compressed, parallel with the embryo. Examples, *Paspalum*, *Olyra*, *Setaria*, *Pennisetum*, *Penicillaria*, *Cenchrus*. Tribe 4. *Stipaceæ*. Spikelets one-flowered; lower palea involute, awned at the apex, becoming undulated at maturity; awn simple or trifid, generally twisted and articulated at the base; ovarium stipitate; scales usually three. Examples, *Stipa*, *Aristida*. Tribe 5. *Agrostideæ*. Spikelets one-flowered, rarely with a subulate rudiment of a second flower; glumes and paleæ

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membranous, the lower palea often awned; stigmas usually sessile. Examples, *Agrostis, Cinna, Sporobolus, Polypogon, Gastridium.* Tribe 6. *Arundinaceæ.* Spikelets one-flowered, with or without the pedicel of an abortive flower, or many-flowered. Flowers generally surrounded by long, soft hairs; glumes and paleæ two, membranous, the former as long or longer than the florets; the lower palea either with or without an awn. Examples, *Arunda, Calamagrostis, Phragmites, Ammophila, Deyeuxia.* Tribe 7. *Pappophoreæ.* Spikelets two or many-flowered, the superior ones withering; glumes and paleæ two, membranous; lower palea trifid or multifid, the segments subulately awned; inflorescence capitately spicate or panicled. Examples, *Amphipogon, Pappophorum.* Tribe 8. *Chlorideæ.* Spikelets collected into unilateral one or many-flowered spikes; the upper flowers incomplete; glumes and paleæ two, membranous, the latter awned or awnless; glumes adnate to the rachis, persistent; spikes digitate or panicled, rarely solitary; rachis not articulated. Examples, *Cynodon, Spartina, Chloris, Eleusine, Digitaria.* Tribe 9. *Avenaceæ.* Spikelets two or many-flowered, the terminal flower usually incomplete; glumes and paleæ two, membranous; the lower palea usually awned, the awn generally dorsal and twisted. Examples, *Deschampsia, Aira, Lagurus, Trisetum, Avena, Danthonia, Triodia, Arrhenatherum, Corynephorus.* Tribe 10. *Festucaceæ.* Spikelets many-flowered, rarely few-flowered; glumes and paleæ two, membranous, rarely coriaceous; lower palea usually awned, the awn never twisted; inflorescence generally panicled. Examples, *Sesleria, Poa, Glyceria, Catabrosa, Briza, Melica, Koeleria, Dactylis, Cynosurus, Festuca, Bromus, Bambusa, Nastus.* Tribe 11. *Hordeaceæ.* Spikelets three or many-flowered, seldom one-flowered; the terminal flower incomplete or rudimentary; glumes and paleæ two, herbaceous, the former sometimes, but seldom, wanting; stigmas sessile; ovarium generally pilose; inflorescence simple, solitary spikes; rachis rarely articulated. Examples, *Hordeum, Triticum, Agropyrum, Secale, Elymus, Lolium.* Tribe 12. *Rottboelliaceæ.* Spikelets one, two, rarely three-flowered, lying in the cavities of the rachis, either solitary or in pairs, one of which is pedicellate and often rudimentary; one of the flowers, when two, is usually incomplete; glumes one or two, but sometimes none, usually coriaceous; paleæ membranous, rarely awned; styles one or two, sometimes very short or wanting; inflorescence spiked; rachis usually articulated. Examples, *Nardus, Lepturus, Rottboellia.* Tribe 13. *Andropogoneæ.* Spikelets two-flowered; lower flower always incomplete; paleæ thinner than the glumes, usually hyaline. Examples, *Perotis, Saccharum, Erianthus, Andropogon, Cymbopogon, Ischæmum.*

Second grand division. *Cellulares,* De Candolle; *Acotyledones,* Jussieu; *Cryptogamia,* Lin.—Vegetables composed principally of cellular tissue, always a truly homogeneous body in their first existence. Reproductive organs not evident. See pp. 53 and 54.

First class. *Semivasculares,* or *Ætheogamiæ,* De Candolle; *Ductulosæ,* Jussieu.—This class is composed of plants which on their first existence are destitute of vessels and stomata, but afterwards acquire them in more or less abundance. See pp. 53 and 54.

267. *Characeæ,* De Candolle.—Fructification in the axils of the branches composed of two kinds of organs. 1. Lenticular disks dehiscing by triangular valves, which are red in the centre and white upon the edges on short pedicels, hanging from the sides of the young branches, each containing five or six tubes which are open at one of the extremities, diverging from a cellular base, and from which rise a great number of threads which are longer than the tubes. 2. Sessile sporangia rising from the interior of the branches of an ovoid or spherical shape, formed exteriorly of five spiral and adherent tubes, and terminated by five distinct teeth, each sporangium containing a spiral striated spore, inserted in the bottom of the cavity and filling it, containing an infinity of unequal globules; in germination, the spore splits in the upper part into five small valves, the centre of each corresponding to one of the rays of the spore; from this opening issues a tube and roots, the origin of which is hidden in the spore; at the summit of the tube is a cellule which forms a second joint, and of other lateral cellules which form the whorls of roots and branches. Composed of aquatic, immersed, articulated, greenish plants, usually covered with a calcareous, crustaceous matter, having both roots and branches in whorls around the joints; the branches sometimes bifurcate, or emitting other whorls of filiform branches similar to leaves; joints of stem and branches composed each of a cylindrical tube made up of a single cellule, often marked by rays which appear longitudinal, but which, in fact, are spiral and interrupted by bands. These rays are composed of green globules, visible only under a powerful microscope; the interior of which is an infinity of globules suspended in a circulating liquid, which has been observed to have an ascending and descending current. *Chara* makes very good manure for some lands by the calcareous excretion produced on the surface. Examples, *Chara, Nitella.*

268. *Equisetaceæ,* De Candolle.—Fructification disposed in terminal cones, consisting of peltate scales; sporules surrounded by elastic, clavate filaments, enclosed in thecæ arising from the scales; the vernation straight. The cuticle abounds so much in silex as to render the species of use in polishing, particularly that of *Equisetum hyemale.* Example, *Equisetum.*

269. *Filices,* Jussieu.—Fructification composed of sporules enclosed in thecæ arising from the back and margins of fronds; vernation circinate. This family is divided into the following tribes. Tribe 1. *Ophioglosseæ,* Hooker. Fructification disposed in simple or branched spikes; thecæ one-celled, two-valved, destitute of a ring; vernation straight; stems hollow. Examples, *Ophioglossum, Lunaria, Botrychium.* Tribe 2. *Osmundaceæ.* Thecæ terminating a leafy frond, dehiscing lengthwise, one-celled, two-valved, without any ring; vernation circinate; stems solid. Examples, *Osmunda, Todea, Lygodium, Schizæa.* Tribe 3. *Marattiaceæ.* Thecæ sessile, without a ring, many-celled. Examples, *Marattia, Danæa.* Tribe 4. *Gleichenieæ.* Thecæ girded by a complete, striated, transverse, rarely oblique ring, nearly sessile, dehiscing lengthwise inside. Example, *Gleichenia.* Tribe 5. *Polypodiaceæ.* Thecæ rising along the nerves or edges of the back of the frond, one-celled, dehiscing transversely and irregularly, with an articulated, elastic, more or less complete ring, which is vertical or a continuation of the footstalk of the thecæ. Examples, *Polypodium, Aspidium, Asplenium, Onoclea, Blechnum, Adiantum, Hymenophyllum.*

270. *Marsiliaceæ,* R. Brown.—Sporules contained in thecæ, which are contained within closed involucra. Arnott. This order is divided into the two following tribes. Tribe 1. *Salviniceæ.* Fronds spread out into



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limbs, not circinal, bearing spores and granules on both sides in distinct, one-celled envelopes. Example, *Salvinia*. Tribe 2. *Marsilieæ*. Fronds circinal; sporangia many-celled, bearing two kinds of organs. Examples, *Pilularia*, *Marsilea*.

271. *Lycopodiaceæ*, Swartz.—Thecæ axillary, one, two, or three-celled, one, two, or three-valved, coriaceous, opaque, containing one or more sporules; vernation circinate. The powdery matter contained in the thecæ is highly inflammable, and is collected in quantities from the common Club-Moss, and is said to explode in water. It is used in theatres to produce artificial lightning. Fronds simple or divided. This family is divided into the following tribes. Tribe 1. *Isoetideæ*. Thecæ dehiscent. Example, *Isoetes*. Tribe 2. *Lycopodeæ*. Thecæ dehiscent, two or three-valved, without a ring. Examples, *Psilotum*, *Lycopodium*.

Second class. *Cellulares*, or *Amphigamiæ*, De Candolle; *Acotyledones*. Sect. 2. *Eductulosæ*, Jussieu. Plants composed of cellular tissue only, and are seldom furnished with stomata.

First sub-class. *Foliaceæ*. Plants frondose or leafy.

272. *Musci*, Jussieu.—Sporules contained in thecæ, closed by an operculum or lid, which usually falls off; stem with leafy appendages. Arnott. Example, *Hypnum*, and all true mosses.

273. *Hepaticæ*, Jussieu. — Sporules contained in thecæ, which are generally dehiscent, and always destitute of an operculum or lid; plants with foliaceous appendages or fronds. Arnott. Examples, *Jungermannia*, *Marchantia*.

Second subclass. *Aphyllæ*. Plants leafless or destitute of leafy appendages, always without stomata.

274. *Algæ*, Jussieu. Sporules variously disposed. With few exceptions the plants of this family are found in water. All sea-weeds, as well as *Confervæ*, belong to this order. The Red Snow Plant of the North, the Dulse and Tangles of Scotland, the *Laver*, which is brought to table stewed as a luxury, are all of this family. Many species are used in other countries as food.

275. *Lichenes*, Jussieu.—Sporules lying in superficial disks. Plants never growing in water. The Iceland Moss contains a large portion of mucilage. It is a tonic, demulcent and nutritive, and many other plants of this family are nearly equal to it. The Orchale and Cutbear, and some other species of the order, are noted for the dye they contain. The plants are also useful in the economy of nature, as preparing the surface of the earth for the reception of larger vegetables. Example, *Lichen*, and all the genera separated from it.

276. *Fungi*, Jussieu.—Sporules in the substance of the plant, the whole of which may be viewed as organs of reproduction. Some of the plants of this order are wholesome, but the greater mass are poisonous; among the former the Mushroom and the Trufle stand conspicuous. The mould of cheese, the ergot of corn, the rust of the rose, the dry rot in wood, are all of this family. Amadou or German tinder is prepared from some kinds of *Boletus*, and afterwards impregnated with nitre.

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## AN ALPHABETICAL LIST OF THE NATURAL FAMILIES.



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# ZOOLOGY.

## SECTION I.

### GENERAL VIEW OF THE ANIMAL KINGDOM, AND OF THE CIRCUMSTANCES DISTINGUISHING IT FROM THE VEGETABLE KINGDOM.

*Introduction.*

It is the province of that part of Natural Science called Zoology (*ζῶον, a living being*, and *λόγος, a discourse*) to inquire into and determine the circumstances of animal existence, to examine and compare the organs of which animals are composed in relation to their habits and manners, to dispose and arrange animal forms connected by similarity of structure and function into groups, to point out their distribution over the earth, and to show the services they render in the general economy of Nature.

Zoology has been divided into three sections: 1st. *Zoography*, (*ζῶον*, and *γράφω, I depict*,) which points out the various external marks characterising and distinguishing animals from each other, and connecting them in their various relations to surrounding objects:—2dly, *Zootomy*, (*ζῶον*, and *τέμνω, I cut*,) by which their internal structure is unfolded and its influence upon their external developement shown. To this branch, when employed in the comparison of organs by which the same functions are performed in different animals, is commonly applied the term *Comparative Anatomy*. And, 3dly, *Zoonomy*, (*ζῶον*, and *νόμος, a law*,) or as it is generally, but improperly, called *Physiology*, (*φύσις, nature*, and *λόγος*,) which explains the uses of the different organs of animals, and the laws by which their actions are directed and controlled.

This division of the subject is, however, as arbitrary as useless, the several branches being so closely interwoven with each other, that it is absolutely necessary to become acquainted with all in order fully to comprehend either, or to obtain any just notion of the various and varied circumstances of the animal organization and economy.

Division of Natural Bodies into Inorganic or Inanimate, and Organic or Animate. Circumstances upon which this Division depends.

All natural bodies are divisible into two kinds, of which their composition, origin, growth, and endurance, are the most apparent characters. In the *one* kind, each body is composed of an assemblage of similar particles, and if broken into pieces however small, is nothing changed but in bulk, every fragment still retaining the same properties as the mass. It originates in that disposition which particles of the same kind have towards each other, called *Attraction*, and which, if not counteracted by other causes more powerful, leads on to their increase of size or growth by *Aggregation*, or heaping together of additional particles upon their external surface to an indefinite extent; thus are they of indeterminate size and form, though not unfrequently, as in crystals, assuming angular forms with plane surfaces. When once formed, the particles remain the same actually as at their original production, are never replaced by others even of the same kind, but so long as under those circumstances which favoured their congregation, remain the same unchanged parts of the same mass. In the *other* kind, the body consists of an assemblage of very dissimilar materials, and therefore not brought together by attraction, which are disposed so as to form threads or fibres of various kinds arranged in cords or sheets, or cells or tubes, and of these the latter two contain fluids. It is always the product of another being, the properties and qualities of which it enjoys, and it grows by assumption into itself of other and dissimilar matter, which, having *absorbed* or sucked up into its cells or tubes, it there elaborates and converts into nutriment which is employed for its developement from within. This conversion of extraneous materials by an internal elimination into the actual substance of the body itself, necessarily implies the existence of an apparatus or set of *organs* for that purpose, and hence every body so furnished is called an *Organic Body*, in contradistinction to those of the former kind, which, not requiring organs, and therefore not being furnished with them, are termed *Inorganic*. The bulk of an organic body is also determinate; it never exceeds that size or form allotted to it at its first creation, and, instead of presenting angles and plane faces, its disposition is always towards the production of curved lines, and more or less rounded and irregular forms. Its endurance is also bounded, and after a certain period it ceases to exist in its own peculiar form.

If the inquiry be carried on, it will be found that the conditions of existence of inorganic and organic bodies are widely different. The former are completely under the control of chemical laws; they are formed either by the aggregation of particles of any single elemental substance, or by the compounding of any two elements having a mutual attraction for each other, the result of which is a third body possessing different properties from those which belonged to either of its components; of the former kind, any mass of pure metal, as gold, silver, &c. is a familiar example, and of the latter water, a liquid fluid which is produced by the combination of two gaseous fluids, hydrogen and oxygen. Such combinations, however, as those presented by inorganic bodies never include in their union more than two elements, and are hence called *binary combinations*. The formation of these bodies is either natural or artificial; we can by operating on salts, either natural or artificial, one of the bases of which is a metal, produce the latter in a metallic form, or, on the contrary, by the addition to a metal of some acid or other substance for which it has affinity, convert it into a salt, and thus exhibit ocular proof of what is constantly, though not so obviously, going on in nature. The metal or salt in either case thus produced remains and would remain the same for an indefinite period as to the actual particles of which it is com-



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posed, were its combination not disturbed by other and more powerful influences which occasionally break up the connection. Organic bodies are remarkably distinguished from the preceding, by the elemental substances of which their peculiar proximate principles consist, being not only uncontrolled by chemical laws, but existing in direct opposition to them, either by producing combinations of three or four elementary substances, hence called *ternary* or *quaternary*, or by resisting the action of chemical agents upon the substances of which they are composed, so long as they remain in organic relations. They cannot be simulated by any artificial operation, nor can they, when once resolved into their original elements, be reproduced by chemical art. The materials of which they are constructed are constantly undergoing change; no organic body is for an instant composed of the same identical parts; of similar materials it is true they always consist, but these are incessantly changing place and combination in the several parts of the body, or are entirely discharged from it, whilst others are received into it and enter into the same conditions as those which have been previously thrown off.

From these observations it is evident that organic bodies must be endowed with some peculiar power, placing them beyond the control of that influence which governs inorganic bodies, and of which the organic structure is one of the manifestations. That this power must be the cause and not the consequence of organization, may be fairly inferred, as in the earliest rudiment of organic matter, no trace of an organ has been found, and it is only as this power is put in action that the organs are gradually formed. This power is called Life, and, therefore, all bodies in which it does not operate, or which it does not protect from chemical agency, are said to be *Inanimate;* whilst those in which its presence is shown by the excitement of actions under favourable circumstances to the production of organs, and by liberating from chemical influence the materials necessary for their support, and converting them into organic matter, are called *Animate Bodies.*

The *characters* which distinguish animate or organic beings from inanimate, inorganic, or brute matter, may be comprised under the following heads, viz.:

1. That they are always produced or generated by other beings, which they resemble in their natural and physical properties, and that their developement is gradual, the first germ of the living being exhibiting no indication of what its future and perfect form shall be; at least "the germ of all animals, so far as has been traced, certainly of all vertebrated animals, being merely a round disk of homogeneous matter, with no difference of form corresponding to the difference of the animals;"* although the regularity with which the process passes through its several stages is so constant, that there cannot be doubt of the capability of the power which first excited the action to control it according to such plan as was originally determined.

2. That they grow by internal absorption and not by external deposit.

3. That they are capable of extracting from the surrounding elements materials from which they construct and nourish themselves, and which they retain uncontrolled by chemical agency. And

4. That they exist only in their organic form for a certain definite period, after which the materials composing them cease to retain their peculiar connection, and, separating from each other, are again subjected to the laws which control inorganic substances.

Such are the general manifestations which in an organic being indicate its endowment with that peculiar principle or property we call LIFE. But what is Life? On this question much has been said and written but to little purpose; some hold that organization is the cause of life, and others that life is a subtile and mobile fluid superadded to matter: both opinions are of about equal value, and equally valueless in imparting any just notion on the subject. All we know of life is that which its manifestations exhibit, but of its essence we are, and probably shall remain, ignorant; for, as Mr. Hunter expresses it, "Life is a property we do not understand, we can only see the necessary steps leading towards it."*

Life may exist under two conditions, either as a passive or an active state of being.

*Passive Vitality*, if it may be so called, "the power of self-preservation, or in other words, the simple principle of life," as Mr. Hunter calls it,† is exemplified in the undecayed existence of seeds which have remained without germination for hundreds of years. A remarkable instance of this kind is mentioned by Dr. Lindley,‡ who records the growth of three raspberry plants from seeds taken out of the stomach of a person whose skeleton had been found in a barrow near Dorchester, thirty feet below the surface of the earth, and buried probably sixteen or seventeen hundred years since. So also eggs remain for months in this state of passive vitality, yet are still capable of incubation. From these circumstances it appears that vitality does not necessarily imply activity, but that it may exist in a passive state, protecting the organism with which it is connected from the operation of those chemical agencies, which would act upon it were the vital principle withdrawn, as when either the seed or egg is placed in a favourable condition for its evolution, the vital activity is excited, and a plant or animal produced.

*Active Vitality* possesses not only the power of resisting the laws which govern inorganic matter, but it also exhibits such actions as are necessary for the sustenance and developement of the living being. These actions are not, however, at all times in the same state of activity; thus, in plants, the ascent of the sap is either entirely arrested or checked during winter, and consequently at that period growth is suspended; but in spring this function is brisk, and its activity evinced by the shooting of buds, twigs, and leaves. An analogy to this modified active vitality is also presented by those animals which hybernate or sleep during winter; thus the marmot, which sleeps during the cold season, and subsists only upon the fat previously collected for that especial purpose on its body, does not respire, when in that state, more than fourteen times in an hour, whilst, on the contrary, in summer time, when actively employed, its respirations are about five hundred in the same period; so also the pulse of the hamster in its torpid state is only fifteen, but when awake and moving about, its pulsations are one hundred and fifty in a minute.§ In whatever state, however, vitality exists, either passive or active, and whether influencing living beings of the most simple or complicated structure, it has its determinate and certain

* Alison, *Outlines of Human Physiology*, p. 7

* *Treatise on the Blood*, p. 90. † Hunter, *loc. cit.*, p. 79.
‡ *Introduction to Botany*, p. 358.
§ Carpenter, *Principles of General and Comparative Physiology*, p. 142.

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end in death; immediately upon the occurrence of which the elemental substances composing the previously living being are set free from the control of the vital power, are again subject to the laws governing inorganic matter, and, resuming their natural combinations, the organized mass is soon destroyed by decomposition.

### Division of Animate Bodies into Vegetable and Animal Bodies.

All living beings are endowed with organs, or means of providing for their *Nutrition* and *Reproduction*, which are absolutely necessary for their support and continuance; but all do not possess organs of *Sensation* and *Motion*, which are, however, equally necessary to those to which they are furnished. The former functions, Nutrition and Reproduction, exist in all organic beings, and are called *Organic Functions;* but as they alone are found in vegetables, they have often been called the *Vegetative Functions*. The latter, viz., Sensation and Motion, occur only in animals, for reasons hereafter to be noticed, and are called *Animal Functions*. This restriction of the living functions to only two in vegetables or plants, and its extension to four in animals, at once determines the line of demarcation between these two great sections of animate beings, and puts aside the more beautiful than correct notion formerly held, that vegetables and animals were connected by intermediate links, participating in the functions of both; for which reason, many of the lower animals, whose external form had some resemblance to plants, were supposed to be plants participating in animal properties, and were hence called *Zoophytes* or *Animal Plants*. Their true place among animals has, however, long since been awarded to them, although they still retain the name of Zoophytes.

### Organic Functions.

#### *Nutrition and Reproduction.*

The Organic or Vegetative Functions are those which have the same objects, both in the vegetable and animal kingdoms, viz., the support of the living being and its propagation; the former, *nutrition*, includes *absorption*, *assimilation*, and *excretion*, and the latter *generation;* but a cursory examination will exhibit very distinct circumstances, characterising each, and distinguishing each from the other.

#### of nutrition.

#### *Comparison of the Elemental Substances entering into the Composition of Vegetables and Animals.*

The components of all organic bodies may be reduced to nineteen or fifteen of the fifty-two elemental substances of which inorganic bodies consist.* These are

| | | |
|---|---|---|
| Oxygen, | Potassium, | Iron, |
| Hydrogen, | Sodium, | Manganese, |
| Carbon, | Calcium, | Chlurine, |
| Nitrogen, | Magnesium, | Iodine, |
| Sulphur, | Silicium, | Bromine, |
| Phosphorus, | Aluminium, | Copper, |
| | Gold. | |

All these elements are found in plants, but aluminium, gold, and copper are not found in animal substances; nor was silicium admitted as one of their constituents till the recent discoveries of Ehrenberg, who has shown that it enters largely into the armour of some of the infusories. In vegetables, potassium exists more largely, whilst in animal substances sodium preponderates. Vegetable substances are principally composed of carbon, oxygen, and hydrogen, with a rare addition of nitrogen; this latter element is, however, a very important ingredient in animal matter, and its union with hydrogen producing ammonia, is one of the strongest characteristics of decomposing animal structures.

The elements combining to form the peculiar proximate principles of organic bodies are, as already mentioned, distinguished from those forming inorganic or mineral compounds, which are always *binary*, by three or four elements uniting equally together, and effecting *ternary* or *quaternary* combinations. Of ternary compounds, examples are afforded in vegetable mucus, starch, and adipose or fat-matter, which consist of oxygen, carbon, and hydrogen; whilst gum, albumen or egg-white, fibrine, animal mucus and resin, including also nitrogen among their elements, are instances of quaternary combinations. Whether the mineral ingredients in organic bodies assume ternary or quaternary combinations, or whether they exist only in a binary form, is still an undetermined question; but many of them exist either as *binary compounds of mineral substances only*, as for example, phosphate of soda, of lime, of magnesia, carbonate of lime, muriate of potash, of soda, fluoride of calcium, silica, oxide of manganese, of iron, and soda, or as *binary compounds of organic with mineral substances*, of which albuminate of soda and lactate of potash and soda are instances.

From the simple elements just enumerated, or from their compounds, it is generally admitted that plants are able to generate organic matter, as well as to assimilate other organic matter to their own. Such, however, is not the case with animals; they are incapable of elaborating organic matter from the simple elements or their compounds, which must have previously acquired vitality in plants before their conversion into animal matter, which can only be primarily produced from vegetable substances, or secondarily from other animal matter.

In the nutrition of both vegetables and animals, it is necessary that the food received into the system should be in a state of solution before it can be rendered available for that purpose. The reason for this is apparent in the greater facility with which fluids can be transported through the different parts of a plant or animal than could solids. It is also certain, that fluidity or moisture in various degrees is a most important condition of organic being, as exemplified in the fluid state of sap and serum, and the softness of the solid organized tissues, four-fifths of the weight of which depend upon the water they contain, though they cannot be said to be wet, or are able to moisten other substances in contact with them. In reference to the latter point, Berzelius notices that the water does not appear in chemical combination with them, as it escapes gradually by evaporation, or can be at once extracted by strong pressure. And Chevreul states, that pure water alone can produce the phenomenon of perfect softening, although salt water, as well as alcohol, æther, and oil, may be absorbed by dried animal parts.*

#### *Comparison of the Mode of receiving Nutriment into the Vegetable and Animal Systems.*

From the various forms of mineral and organized bodies by which they are surrounded, *Plants* suck up or

* Müller, *Handbuch der Physiologie des Menschen*, vol. i. p. 1.

* Müller, *loc. cit.*, p. 7.



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absorb into their vascular system, by means of the spongelets at the extremities of their roots, the fluid substances upon which they feed, and convey them through vessels to be deposited in such parts as the need of the plant may require, without, so far at least as at present known, undergoing any change previous to their deposition. And as the nutritive matter is always absorbed at one extremity, so does the growth of the plant take place at the other extremity, as it would seem without any determinate plan, but in such directions as are most favourable to the nutritious juice or *sap*.

In *Animals* the nutritive matter may be either fluid or solid, animal or vegetable, or both, but whichever it be, or however different the substances of which it consists, it must all be received into a cavity called the *Stomach*, where, by action of the gastric juice or rennet, it is converted into an uniform pulpy mass known as *Chyme*. This process is called *Digestion*, and does not occur in plants; it is specially an animal function, and allotted to them because their absorbing vessels not opening externally as in plants, and their nutriment, even were such the case, being of various kinds and not in that minute state of division in which it exists in the soil from whence plants spring and derive their food, requires to be reduced to an analogous state before the absorbing function in animals can be performed. The chyme is, therefore, to the animal body what the soil is to the vegetable; and as the whole mass of the soil is not composed of nutriment, neither is the chyme, part only is nutritious, and the rest feculent. The nutritive part of the chyme is called *Chyle*, which, in such animals as have merely a simple cavity or stomach, is at once extracted from the digested mass and carried by a series of minute vessels, opening upon the internal surface of that organ, like the spongelets at the extremities of the roots of plants, into the system. In a large proportion of animals, however, there is attached to the stomach a tube called an *Intestine;* in such, the elaboration of the chyle is more complicated, and it is thrown down or precipitated by the bile poured forth from the liver, and is observed sticking to the mouths of the absorbing vessels, which in this kind of nutritive organ are found only on the surface of the intestine and not on that of the stomach.

Of that feculent or excrementitious part of the food which remains after the actual nutriment has been extracted and absorbed, the more bulky part is discharged by the descending vessels which open in the roots of plants. But in animals the unnutritious part of the food is either at once rejected from the simple orifice of the stomach by which it had been received, if that organ be a simple sac, or if there be an intestine, it passes through it and is discharged at its extremity or vent, the position of which is very variable.

*Comparison of the Respiratory and Circulating Systems in Vegetables and Animals.*

The nutritious fluids being thus separated, as sap in plants, and chyle in animals, are not however fitted for their nourishment, that is, are not really vegetablized or animalized, until they have undergone some important change by exposure to the action of the air; and this naturally leads to the consideration of the apparatus by which such exposure is effected, and also that by which the fully perfected nutrient juices are conveyed throughout the vegetable and animal body; in other words, to examination of the *Respiratory and Circulating Organs.*

*Respiratory System.*—The support of the living principle both in plants and animals is materially dependent on the atmosphere by which they are surrounded; but the change taking place in the nutritive fluid of each by the action of the air upon it, or by the action of the vegetable or animal economy upon it, is widely different.

The breathing organs of plants are their leaves, in which the sap-vessels exposed to the action of the atmosphere give out, at least during the day, a very considerable quantity of oxygen gas, abstracting at the same time from the air its carbonic acid gas, which, being converted into carbon, is deposited in the plant to form its substance or solid part.

In animals, the breathing organs of the lower classes resemble those of plants, consisting only of the expansion, upon the surface of the body, of the branches of vessels containing the nutritive juice, whereas in the leaves of plants, they are operated on by the surrounding atmosphere, with this marked difference, however, that instead of giving off, they absorb oxygen, and in place of abstracting carbonic acid gas, they increase its quantity, by discharging it from the nutrient juice into the atmosphere. This done, the chyle becomes converted into blood, that is, arterial blood, which is alone capable of supporting the animal functions.

This process, called *respiration*, is in most classes of animals performed by a peculiar set of organs called respiratory; consisting of *gills*, when the animal inhabits the water, or of *spiracles* or *lungs* when it lives upon land. The effect thus produced upon the nutritious fluid of animals is called its *aeration*, by which the chyle is converted into blood, and rendered fit to support animal life. It also not only thus animalizes the chyle, but operates upon that blood which had been previously circulating in the body, separating and discharging from it the deleterious carbon acquired in the course of circulation, (and which is to be considered as an excrementory process, or one of those by which the hurtful, useless, or worn-out parts are withdrawn from the system,) and revivifying it by the absorption of oxygen.

*Circulating System.*—This in vegetables consists of an *ascending series* of very delicate tubes, which, springing from the roots of the plant, rise through its stem and branches in parallel bundles and pass into its leaves; but as they proceed to this destination without giving off any branches, they are of equal size at their upper as at their lower extremity. They carry the sap upwards, and terminate in another set of tubes called the *descending*, which commencing on the leaves run downwards, depositing the sap through apertures in their sides, and terminate by open mouths in the roots of the plant.

In animals, the origin of the circulating tubes presents a remarkable distinction from vegetables; they do not arise as in plants from the external but from the internal surface, from the interior of the stomach or intestine in which the food has been digested and fitted for the selection of the absorbing vessels, which, as Boerhaave expresses it, are true internal radicles, and thence convey it throughout the system. In the most simple animals the circulation is, as in plants, performed by vessels alone; with this important difference, however, that whilst in plants the tubes never ramify, in animals they branch off into numerous smaller vessels freely anastomising or opening into each other, till at last the primary trunk disappears, and in its stead is produced a network of very minute vessels, by which the animal body is nourished. These vessels terminate in others equally minute, which,

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gradually collecting together, form by their union larger and larger trunks, corresponding in size to the trunks from which they originally sprung.

The difference between plants and animals becomes still more marked, as the structure of the latter becoming more complicated requires greater activity in the circulating organs; a circumstance especially connected with the developement of special respiratory organs, and hence leading to the production of a contracting reservoir or *heart* from whence the nutritive fluid is propelled. The heart varies in kind and in function; in some animals it impels the blood through the respiratory organs alone; in others, on the contrary, through the general system with the exception of those organs, whilst in the higher classes it pumps the blood synchronously through both the respiratory and general systems. In this respect, then, the distinction between plants and animals is well defined, especially in the higher classes of the latter, and it is no less distinctly, though not so strikingly, shown in the lower classes, by the division of the vessels or tubes into their minute ramifications.

*Comparison of the Circulating Fluids of Vegetables and Animals; viz. Sap and Latex; Chyle and Blood.*

The SAP or circulating fluid of plants is colourless, essentially aqueous, and of similar character in all plants; in some, however, it contains albumen, or a matter similar to gluten, and in others sugar, &c. It holds in solution the nutritious particles upon which the plant feeds, but yields up none of them till it has passed through the leaves, and been exposed to the action of the air. In its progress it becomes less watery, as it attains a greater distance from the root, and perspires by its leaves so considerably, that, according to Hales, the perspiration is seventeen times greater than in the human body.

The cause of the ascent of the sap has been variously stated by different writers, but the opinion of Du Petit Thouars appears the most reasonable, viz., that it is excited by the expansion of the leaves; for in the spring, so soon as the extremities of the branches and buds begin to swell, the sap is attracted from the neighbouring tissue, which being refilled from that below, and that replenished by the next, the sap is put in motion from the extremities of the branches down to the roots, which being emptied of their contents, immediately commence the absorption of more nutriment from the soil.

Having been vegetablized and fitted for nourishment in the leaves, it passes into vessels principally in the bark, where it is usually found of a viscid character, insoluble in water, more or less opaquely white, yellow, red or brown, or transparent and colourless, depending upon the oscillatory motions of organic globules which it contains, and which are considered by Schultz to be its *living part*, and distinguished from all other secretions in the vegetable parenchyma, viz., ethereal oil, resin, and gum, in which there are no globules. This fluid is called

The LATEX, and upon exposure to air it separates into a *coagulum* or *clot*, tenacious and elastic, sometimes resembling caoutchouc, and into *serum*. Escaping through the sides of the vessels in which it is contained, the latex is deposited in such parts as require nutriment; and that nutrition is its function, is proved by the extreme injury which a plant suffers by the loss of only a very small quantity of it, and by its large distribution in those parts in which the greatest increase in plants occurs, during the season of developement.

The motion of the latex,* which has been called *cyclosis* by its discoverer Schultz, takes place through a series of reticulated vessels in all directions; the currents rising in some and falling in others which are parallel and near together, or to the right or left in those which are lateral, or connecting vessels, depend essentially on the oscillatory motion of the globules themselves, which have an incessant tendency to unite and to separate without either tendency ever overcoming the other; whilst its secondary causes result from the operation of heat, endosmose, light and contraction excited by irritability, not a pulsatory contraction, however, but a simultaneous contraction of the whole length of the vessel.

The refuse of the sap, neither perspired nor employed as nutriment, nor discharged by respiration, descends to the roots, and there as deleterious matter is discharged from the plant into the soil. That such is the case with all vegetables is proved by the experiments of Macaire, who found that from some opium, from others gum, and from others alkaline and earthy alkalies, and carbonates of an acrid gum-resinous substance were excreted.

The CHYLE of animals may be compared to the sap of plants, inasmuch as both present the first step in the assimilation of the food; it "is the immediate effect or product of digestion," as Mr. Hunter says, "and is the seed which, as it were, grows into blood, or may be said to be the blood not yet made perfect;† neither being capable of affording nourishment till after exposure to the action of the air. The chyle also coagulates, but the products of its coagulation are very different from those of sap. The *coagulum* or *clot* of chyle is, in the higher animals at least, of an opaque white colour with a sweetish saline flavour, and closely resembles the cheesy part of milk; it may therefore be considered as a variety of albumen. The *serum* when evaporated to dryness leaves a small portion of a substance resembling the sugar of milk.

It is here sufficient only to notice that the chyle is poured into the venous system, where, mingling with other matters in solution, which have been absorbed from all parts of the body, and with the blood immediately prior to its circulation through the respiratory organs, the whole mass of fluid passes through those organs, whence, having been acted on in some peculiar manner by the air, the effect of which is the throwing off a large quantity of carbon and the change of colour, it reappears in the form of arterial blood fitted for the nutrition of the animal, and may then be compared to the latex of plants. The conversion of chyle into blood is said by Autenrieth to be effected in ten to twelve hours, because up to that time the serum is milky; but Müller thinks that the change takes place more slowly‡.

The BLOOD is, as is well known, in the higher and also in some of the lower classes of animals, generally of a red colour; but this redness is not essential to it, for in many even of them, and in certain parts of all, the red globules from which it assumes this colour are frequently deficient; as for instance, in the white and transparent parts of the eye. But in many whole classes of animals the blood is never red, but colourless and transparent, and therefore its redness is not an essential part of its composition.

The blood whilst alive and circulating in its vessels has to the naked eye the appearance of an homogeneous fluid, but if examined with a microscope in the foot of a

* Lindley, *loc. cit.*, p. 394. † Hunter, *loc. cit.*, p. 72.
‡ Müller *loc. cit.*, p. 143.

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Zoology. living frog, or in the tail of a small fish, it is seen to consist of two parts, viz., *fluid* and *globules*, the former distending the vessels and hurrying along in it, without any seeming regularity, the latter. These globules are of a spherical or oval form like small bladders, and themselves filled with fluid; their capsules are certainly elastic, as may be seen by their change of form when two or more are hurried by the fluid current into any narrow part of a vessel, and as it were jostle one another till one escapes, and being impelled forward resumes its original form. When the blood is arrested for some time in a vessel, or withdrawn from the circulation either into the surrounding parts of the body, or purposely into a glass vessel, a remarkable change takes place in its character by its separation into two distinct parts, of which one is fluid and the other is solid; the former of these is called serum, and the latter crassamentum, or clot. This process of separation is known by the name of COAGULATION, and is one of the most important processes in the body upon which the life of a part or even of a whole animal very frequently depends; but of its cause nothing satisfactory is really known. Mr. Hunter calls coagulation "an operation of life,"* and there can be little doubt that the nervous system does in some way influence it; for in animals which have had their nervous energy destroyed by over exertion or any other cause, coagulation does not take place, and the blood remains fluid after death.

When the blood escapes from a vessel, it gives off whilst flowing, even under the air-pump, a vapour, which rises from the fluid like steam, and is known as the *aura sanguinis*, or vapour of blood: it consists principally of much water, a little animal matter, and, according to Dr. John Davy, a small quantity of carbonic acid. The residue, and by far the larger portion, of the evacuated blood separates into the serum and coagulum; but though this process commences speedily it is not completed for several hours, as the coagulum, though soon apparently solid, continues to contract itself, and squeezes out more serum so long as its capability of contracting continues.

The SERUM is a more or less limpid fluid of a greenish-yellow or straw colour; its specific gravity is, according to Brande, frequently 1030: it has a faint unpleasant smell and a saltish taste. In its fluid state serum examined under the microscope presents corpuscles of a pretty regular and rounded form, which are very numerous when the fluid in which they float evaporates, and are very minute granules of albumen. They are at an ordinary temperature continually in motion, similar to that which has been observed by Robert Brown to occur when any pulverized body is thrown into a liquid; this motion is not therefore to be considered a vital action.

The chemical composition of serum in the human subject is, according to Berzelius, in 1000 parts,

| | |
|---|---|
| Water | 0.905 |
| Albumen | 0.080 |
| Chloruret of potassium and sodium | 0.006 |
| Lactates of soda united to an animal matter | 0.004 |
| Carbonate of soda, Phosphate of soda, Animal matter } together | 0.004 |
| Loss | 0.001 |
| | 1.000 |

* Hunter, *loc. cit.*, p. 26.

When exposed to a temperature of 160° Fahr. it solidifies into a firm, yellowish-white mass called albumen, from its resemblance to the white of an egg; and from this there exudes a small quantity of fluid known as the *serosity*, which, according to Brande, is a solution of soda. If the serum, coagulated by heat as just mentioned, be dried at a temperature of 168° Fahr., afterwards treated with boiling water, evaporated, and then treated with alcohol, lactate of soda, chloride of potassium and sodium, and osmazome will be taken from it by the alcohol, the unchanged residue is pure Zoology.

1. *Albumen*, which though found in other fluids of the body, is the principal component of serum. It exists, combined with soda in fluid serum, as the albuminate of soda; but Berzelius denies that it is held in solution by means of the soda, as that salt may be saturated by acetic acid without any precipitation of the albumen. If serum be evaporated at a heat below 140° Fahr., it becomes dry, transparent, and soluble in water, but if above 150° Fahr., it coagulates and becomes insoluble. If serum be mixed with water, and heat be applied, the albumen coagulates in globules forming a milky fluid, which, however, when evaporated, still retains its albuminous character. It is coagulated also by galvanism, alcohol, metallic salts, chlorine, infusion of galls, and by a strong solution of fixed alkali. Neither acetic acid, nor the neutral salts, nor æther precipitate it from the serum. Albumen is distinguished from fibrine, another very important animal principle in the blood presently to be noticed, by not coagulating spontaneously, and by not being precipitated by æther. When coagulated, however, albumen consists of aggregated globules, and cannot then be distinguished from fibrine but by not decomposing peroxide of water, which the latter does.

Its elementary composition, according to Michaelis, is as follows:

| | Arterial A. | Venous A. |
|---|---|---|
| Nitrogen | 15.562 | 15.505 |
| Carbon | 53.009 | 52.650 |
| Hydrogen | 6.993 | 7.359 |
| Oxygen | 24.436 | 24.484 |

Whilst its proportions to the other parts of serum are, according to Berzelius,

| | | |
|---|---|---|
| Water | | 90.59 |
| Albumen | | 8.00 |
| Osmazome with lactate of soda | extracted by alcohol | 0.40 |
| Chloride of potassium | | 0.60 |
| Modified albumen, alkaline, carbonate and phosphate | extracted by water | 0.41 |
| | | 100 |

besides which there have also been found the sulphate of an alkali, carbonate and phosphate of magnesia, and phosphate of lime.

2. *Lactic Acid*, another component of serum, is, if obtained by Berzelius's method, colourless, odourless, and of a pungent acid taste; it and its salts are always combined with osmazome, from which it may be separated by infusion of galls precipitating the latter; it is readily soluble in alcohol, whilst, on the contrary, æther dissolves but a very small quantity of it. Lactic acid, besides existing in serum, is found also in other animal substances, as muscle, in the crystalline lens of the eye, and also with its salts in many secretions, especially in the milk, whence it has acquired its name.*

3. *Osmazome*, or the *Flesh Extract* of Thouvenet, is

* Berzelius, *Thierchemie*, p. 576—584.

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 soluble in cold or hot water or alcohol, deliquesces in damp, and melts in warm air, and is precipitated by infusion of galls. It is not considered by Berzelius to be a peculiar principle, but a combination of an animal matter and lactates. It exists also in the saliva and in the pancreatic and gastric juices. It is that which forms the gravy in meat.

4. *Seroline* is another substance which has of late years been discovered in the serum by Boudet; it is opalescent, fusible at about 94° Fahr., not forming an emulsion with water, soluble in alcohol, not saponifiable, and appearing to contain azote.[*]

The Coagulum, Crassamentum or Clot, as it is indifferently termed, is the solid mass observed floating in the serum after coagulation of the blood has taken place, and consists of two different substances capable of separation from each other by washing. The knowledge of these two materials in the composition of the clot was familiar to English writers on this subject of the last century, and they were called *Gluten*, or more properly *Coagulating Lymph* and *Red Particles*, in preference to which they are at present known as Fibrine and Globules.

1. *Fibrine* is so called from being the proximate principle of muscular fibre. When freed from all colouring matter, it is of a greyish-white and opaque, is extremely tenacious and very elastic. Under the microscope it at first presents the appearance of gelatinous matter, or a sort of coagulated mucus spread out into a membrane, in the middle of which are a few little spots and without a trace of fibre, which, however, becomes immediately visible on drawing the film apart. Müller says, that when contracted and become white it has a fine granular appearance,[†] which, however, may perhaps really depend upon irregularity of surface. It is distinguished from coagulated albumen by decomposing peroxide of water, though both are in a state of solution in the blood, as proved by the recent observations of Müller on the blood of the frog.

The same author has also inquired into the proportion which fibrine bears to the mass of blood, and has ascertained that, in 3627 grains of bullock's blood there are only 18 grains of fibrine; and that it is more abundant in arterial than in venous blood, 100 parts of the arterial containing 0.483, and the same quantity of the latter, 0.395;[‡] or in round numbers, as stated by Denis, in the proportion of 25 to 24. The proportion which fibrine bears to the whole mass of the clot has not yet been satisfactorily determined, but Berzelius states that, in 100 parts of coagulum there are 36 of fibrine and albumen, and 36 of colouring matter. When coagulated fibrine has been washed white and dried, it loses three-fourths of its weight, and becomes hard and brittle, yellowish and opaque; it softens, but is not dissolved in water; burns to a greyish-white semifused ash, neither acid nor alkaline, and amounting only to two-thirds per cent. of the weight of the dried fibrine; it consists principally of phosphate of lime, some phosphate of magnesia, and a very small portion of iron, and if dissolved in muriatic acid, silica is found; but neither of these can be obtained previous to combustion, and therefore seem to have entered into the chemical composition of fibrine, and not merely mixed with it. By boiling for a long time its bulk is much diminished, it becomes hard but very easily broken to pieces, and forms a new substance, which, however, contains no gelatine. 

The gaseous elements of fibrine have been examined by Gay Lussac and Thénard, and also by Michaelis, the latter of whom has given them both in arterial and venous blood as follows:[*]

| | Arterial F. | Venous F. |
|---|---|---|
| Nitrogen . . . . | 17.589 | 17.267 |
| Carbon . . . . | 51.374 | 50.440 |
| Hydrogen . . . | 7.254 | 8.228 |
| Oxygen . . . . | 23.785 | 24.065 |

Müller mentions as a characteristic of fibrine, that its solution in acetic acid is precipitated by ferro-cyanuret of potassium, which is not the case with cellular tissue, tendinous substance, nor the elastic tissue of arteries.

2. The *Globules*, as they at first appear to be, are easily separated from the blood whilst flowing from a vessel, by receiving it upon filtering paper, which allows the passage of the fluid part whilst these are retained. Their aggregation was held by Home, and more recently by Prevost and Dumas, and Dutrochet, as the cause of the coagulation of the blood; this notion, however, has been disproved both by Berzelius and Müller, the latter of whom shows that the globules are merely entangled in the coagulating fibrine. In all the vertebrata and in some of the annelid class of invertebrate animals the globules are red; but with the exception just made, they are in all the invertebrate classes nearly colourless, but sometimes blue, bluish, greenish, or yellowish: its redness is not therefore a necessary quality of blood. The red colour of the globules depends on a peculiar principle, *Hæmatosine*, as it is called by Blainville,[†] to distinguish it from the *Hæmatine*, which colours logwood, but by which name it is more commonly known among writers on the blood; it is the *colouring matter* of the blood when fluid, and of its clot when coagulated. The experiments which have of late years been made by Müller[‡] have been with frogs' blood, in which these particles are four times as large as in the mammiferous class, and his observations have been more determinate; but many important circumstances in relation to them had been detailed long before by Hewson, and subsequently by Dr. Young, Prevost, and Dumas, and Hodgkin and Lister. When placed under a microscope, they present in the mammals a circular form, but in birds, reptiles, and fishes an elliptical form; Hewson described them as being flattened, and not globular in all the vertebrated classes, and that they had this shape as well whilst moving along in the vessels as when the blood was withdrawn from them. According to Müller's observation, it is necessary they should be examined in serum and not in water, which destroys their flattened form, and renders both circular and elliptical globular.[§] The flattened form is most distinct in amphibious reptiles, and in the salamander, according to Müller, more decidedly so than in any other animal yet examined.[‖] According to H. M. Edwards, the globules of invertebrate animals are less regular, "their surface is uneven and tuberculated like that of a raspberry; their contour is extremely variable; they change their figure with the greatest facility, and their size is considerable."[¶] Their size is not in relation

[*] *Ann. de Chimie*, 2d series, vol. lii.
[†] Muller, *loc. cit.*, p. 107. [‡] *Ibid.* p. 109.

[*] Berzelius, *loc. cit.*, p. 34—47. R. H. Weber, *loc. cit.*, p. 83.
[†] *Cours de Physiologie générale et comparée*, vol. i. p. 2. 8.
[‡] Müller, *loc. cit.*, p. 93. [§] *Ibid.* p. 96.
[‖] *Ibid.* p. 97.
[¶] *Article* Blood, in *Cyclopædia of Anatomy and Physiology*, p. 406.

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to the bulk of the animal, being smaller in mammals than in birds, and in the latter than in fishes, whilst in the young viper and in the chicken they are larger than in the adult animals; but they are largest in reptiles, especially in the batrachians. Müller states,* that their size is alike in both arterial and venous blood, in opposition to Kaltenbrunner's opinion, who says, they diminish as they pass through the more delicate branches of the arteries into the veins. Various persons have employed themselves in measuring their size especially in human blood. Dr. Young and Dr. Wollaston estimate them at $\frac{1}{5060}$ part of an English inch, whilst Capt. Kater finds them varying between [illegible] and [illegible], and most recently, according to Müller's account,† they are from 0.00023 to 0.00035 of a French inch, which nearly corresponds with the measurements previously quoted. In other animals they have been examined by Prevost and Dumas, Wagner and Owen; the smallest being those of the goat, which are only [illegible] of an English inch, according to Prevost and Dumas, whilst in *Salamandra cincta* and *cristata* their long diameter is [illegible] and the short [illegible] of an inch.

The red globules consist of two parts, an exterior vesicle and a central nucleus, which is circular in the round and elliptical in the oval globules. In some animals this central nucleus appears elevated, but in those of the mammiferous class it is never so, and indeed Dr. Young thinks that the red globules present a central depression in the human blood; in which, however, although extremely small, Müller has observed the nucleus round, well defined, and more yellow and shining than the transparent part by which it is surrounded. If the red globules be put in water, and allowed to continue for some time, the water becomes tinged with their red colour, whilst the globules themselves gradually diminish in size, till at last they do not exceed a fourth of their original bulk, mostly assume a roundish, though a few continue of an oval form, and take on the appearance of colourless, mucuous granules, in which state the nuclei, for such they are, cease to undergo any further change from the action of the water. The cause of this diminution of their size is, that their exterior vesicle, in which the hæmatosine is contained, has been dissolved by the water. That this colouring matter is not dissolved by the serum of the blood, Berzelius is inclined to believe depends upon the albumen which the serum contains; but Müller doubts this as the sole cause, and rather supposes that the salts entering into its composition prevent such effect. As to their chemical composition, the *nuclei* which are insoluble in water are soluble in a solution of soda, or potash, and of ammonia, in which respects they resemble coagulated fibrine and albumen, and they are distinguished from the just mentioned substances by assuming the form of a brown powder when treated with acetic acid, whilst fibrine and albumen are rendered transparent.

The *hæmatosine* has been examined by Berzelius, who finds that in its natural state it has a great affinity for oxygen, which it absorbs when exposed to it, or attracts from the atmosphere, at the same time acquiring a much brighter red colour, and giving off carbonic acid: but by long exposure to oxygen it becomes black, and its red colour cannot be restored. When dissolved in water, and exposed to a temperature of 122° of Fahrenheit, it forms a blackish mass which can be rubbed into a dark red powder again, soluble in water; but if the heat be raised to 158° Fahrenheit, it coagulates and becomes insoluble in water, is red and granular, but becomes black if dried by heat. It resembles fibrine in the change it undergoes by long continued boiling in water, and in forming with acids neutral combinations soluble in pure water. Tiedemann and Gmelin have discovered it to be slowly soluble in alcohol, imparting to it a red colour, and this is a method by which it can be separated from albumen. Its chemical analysis, according to Michaelis, is—

| | Arterial H. | Venous H. |
|---|---|---|
| Nitrogen | 17.253 | 17.392 |
| Carbon | 51.382 | 53.231 |
| Hydrogen | 8.354 | 7.711 |
| Oxygen | 23.011 | 21.666 |

It therefore agrees in its elements with fibrine, but when burnt, leaves a larger quantity of ash, which contains, according to Berzelius, one half it's weight of iron, although Brande and Vauquelin deny that the colouring matter contains more iron than serum and other animal substances. The quantity of ash obtained is estimated by Berzelius at $1\frac{1}{4}$ or $1\frac{1}{2}$ of the weight of the dried hæmatosine, and he found it consisted of

| | |
|---|---|
| Oxide of iron | 50.0 |
| Subphosphate of iron | 7.5 |
| Phosphate of lime, with a small quantity of phosphate of magnesia | 6.0 |
| Pure lime | 20.0 |
| Carbonic acid and loss | 16.5 |
| | 100 |

Oxide of manganese has also been found in the ash by Wurzer.

There has been much dispute among chemists, both as to the existence of iron in the blood, and as to the state in which it exists. It appears certain that previous to incineration not the slightest trace of iron or lime can be found in the blood by the usual and delicate tests for oxide of iron, as ferro-cyanite of potash, tannin, gallic, and the strongest mineral acids; and therefore neither iron nor lime exists in the state of salts. Some have denied that it exists at all, or at least in any greater quantity than in other parts of the body, whilst on the other hand, Menghini says, that dried and powdered blood is acted on by the magnet, which is also denied. Fourcroy held that the colouring matter of the blood was a solution of the subphosphate of peroxide of iron in albumen, and that the iron in chyle was a neutral phosphate of the protoxide: this was disproved by Berzelius,* on account of the subphosphate of the peroxide of iron being insoluble both in serum and albumen. And the opinion of Prevost and Dumas, that peroxide of iron in solution with albumen is the colouring matter, is no more tenable, for, were it so, the iron might be extracted from the colouring matter in its uncalcined state by the mineral acids, and by nitro-muriatic acid. The most recent and important observations, however, are those of Engelhart:† he shows that a solution of the colouring matter in water, if impregnated with sulphuretted hydrogen, gradually loses its colour, and becomes first violet, and afterwards green, just as iron does when similarly treated;

* Müller, *loc. cit.*, p. 105. † *Ibid.* p. 98.

* Berzelius, *loc. cit.*, p. 58.

† *De vera materiæ sanguini purpureum colorem impertientis natura.*

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that from a watery solution of the colouring matter, or from coagulated colouring matter in water, all the iron, magnesium, and phosphorus can be abstracted by a stream of chlorine passing through it, or by a solution of chlorine in water mixed with it, the solution becoming first greenish, and afterwards colourless; the animal matter precipitated in white flocculi combined with chlorine, or hydrochloric acid, and the iron, calcium, magnesium, and phosphorus remaining in the solution combined with oxygen or chlorine; the iron as chloride of iron, the phosphorus as phosphoric acid, and capable of separation by filtering. Now as chlorine has not any affinity for oxides, but a very strong one for metals, and as iron is not extracted from the blood by mineral acids, which have great affinity for metallic oxides, but none for the metals themselves, Berzelius thinks it probable that the iron is not oxydized, but in its metallic state, organically combined with nitrogen, carbon, hydrogen, and oxygen, with a small quantity of phosphorus, calcium, and magnesium, and that by calcination of the colouring matter, these elements are oxydized and form phosphoric acid, lime, magnesia, and peroxide of iron; although there is no similar example of a *quinary* combination of a metal with nitrogen, carbon, hydrogen, and oxygen. H. Rose, however, who has repeated Engelhart's experiments, considers that the iron in the blood is in the state of an oxide;* for he found that in a solution of colouring matter mingled with a certain quantity of persalt of iron, to which ammonia was added in excess, the peroxide of iron remained in solution, and could not be abstracted either by sulphuretted hydrogen, or tincture of galls. But Berzelius considers this combination as not existing in the blood, for if so the iron would be extracted from the colouring matter by acids; as it is from such artificial compounds of colouring matter, or albumen, with peroxide or protoxide of iron.

Wioterl, by carbonizing blood with potash, obtained a substance he called *sanguineous acid*,† soluble in alcohol, which does not, like ferro-prussiate of potash, precipitate iron from its combinations, but imparts to it a red colour; this acid combined with iron Treviranus considers as imparting the red colour to blood.

Besides the matters already described as found in the blood, there exists also

*Fat*, very rarely, however, in its free state, but generally combined with fibrine, hæmatosine, and albumen. Gmelin obtained cholestrine, stearine, elaina, and stearic acid from the first filtering of a solution of hæmatosine in serum, boiled in alcohol.‡ This was first thought by Berzelius to be formed during the process, but he now admits that it is an extract, from having noticed that fibrine is not chemically changed when the fat has been obtained from it by alcohol or æther;§ and he describes two modifications of fat in fibrine, and concludes with observing, that it is very similar to the acid salts of stearic and elaic acids with potash, described by Chevreul, except in being more soluble in æther and alcohol. The quantity of fat in fibrine is, according to the latter author, about four or four and a half per cent.

The fat in the blood is distinguished from the combination of stearine and elaine in containing nitrogen, in partially crystallizing when exposed to cold, and in not being convertible into soap. Like all other fat it is remarkable for the small quantity of oxygen and for the large quantity of carbon it contains.

Müller, therefore, justly concludes that, "If we set aside the new organic materials produced by secretion, as picromel, casein, mucus, &c., the proximate elements of all the solid parts of the body are already contained in the blood, viz. fibrine, albumen, osmazome, lactic acid, and fat. The only exception to this is the *gelatine* or *gluten* existing in tendinous fibre, cartilage, bone, serous membrane, and cellular tissue in general, and in the cellular tissue of muscles in particular."* Some chemists have thought that gelatine does exist; but by others, and Berzelius amongst the number, it is denied. It is a query, however, whether it is not produced by some change of the tissues during boiling. It is insoluble in alcohol or cold water, by which it is distinguished from osmazome, forms a jelly on cooling when diluted with a hundred and fifty times its weight of water, but is again dissolved in boiling water, which distinguishes it from fibrine and albumen.

*Formation of the blood.*—The waste of blood which occurs in the performance of the several functions with which it is connected is repaired by the influx of two fluids, the chyle and the lymph.

1. The *chyle*, which has been already adverted to as the immediate effect or product of digestion, is speedily conveyed by the absorbent vessels of the mesentery, which from their office are called *chyliferous* and from the milk-like appearance of their contents *lacteal*, into the blood after the digested food has passed from the stomach into the intestines, and this process continues only so long as there remains any nutritive matter to be extracted. It is usually turbid, and in Mammalia nearly white, in consequence of the presence of numerous white globules, considered by Tiedemann and Gmelin as globules of fat, but by Müller and most other physiologists held to be true globules of the chyle itself, and not fat. These are of various size in different animals, and are generally smaller than the blood globules; but in the rabbit Müller found some of them larger, though the greater number were very small.† And in the Mammalia which he examined they were globular and not flattened like the globules of the blood. The chyle globules are found first in the lacteal vessels upon the external surface of the intestine; it is not therefore probable that they are generated by the absorbent vessels themselves as supposed by some writers, but whether they are absorbed as globules from the digested food or chyme is not yet decided. They float in great numbers in the fluid part of the chyle, which is coagulable; but it is said that this coagulable matter consists only of albumen till the chyle has passed through the glands of the mesentery where a change occurs in it, after which fibrine is found as well as albumen.

2. The *lymph* differs from the chyle in that it has already been subjected to the effects of circulation, inasmuch as it is the fluid obtained from every part of the body, and receiving in solution those parts which, having either as fluids or solids formed parts of the body and performed certain functions, are, if the expression may be so used, worn out in the service, and become either useless or actually noxious to the economy, and require to be conveyed away, either for abso-

* *Ueber den Eisengehalt im Blute und über den Einfluss organischer Substanzen auf die Ausscheidung des Eisenoxyds*, in Poggendorf's *Annalen*, vol. vii. p. 81.
† Müller, *loc. cit.* p. 119.
‡ Gmelin, *Chimie*, iv. 1163.
§ Berzelius. *Traité de Chimie*, (transl.) vol. vii. p. 46.

* Müller, *loc. cit.* p. 126. † *Ibid.* p. 247.



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lute dismission from the body as excretions, or for the purpose of entering into new combinations by which they can be again used up in the bodily fabric. The vessels in which the lymph is conveyed are called *lymphatic*, and have their origin in every part of the body, as the lacteal derive theirs from the intestines alone; but both empty themselves into common trunks which terminate in the venous system close to the respiratory organs: it has however been much disputed whether the lymphatic vessels do not also empty themselves into the veins at a great distance from the respiratory organ, and even the veins themselves are held by some physiologists to act as direct absorbers of lymph. The lymph is a pale yellowish transparent fluid, and like the chyle contains globules, but these are very few in number and very small, and according to Müller* not more than one-fourth of the size of the blood globules in the frog; they are also like the chyle globules, globular and not flattened. No satisfactory account was given of them till of late years, for Hewson's description of what he considered lymph globules in lymph from the thymus gland and from the spleen is very indefinite; and the lymph described by Soemmering could not have been lymph as it would not coagulate. The discovery of the lymph globules must therefore be assigned to Nesse and Müller,† who, in the winter of 1831-32, had the good fortune to obtain lymph from a divided vessel on the foot of a young man in the hospital at Bonn which long remained fistulous, and they were thus enabled to examine its composition thoroughly. The fluid in which these globules float contains albumen and fibrine in solution, the latter of which readily coagulates when abstracted from the vessel; and this fluid so closely resembles the liquor sanguinis or fluid part of the blood, that, as Müller says, "we may very properly call the latter the lymph of the blood, and consider the lymph as blood without red globules, and the blood lymph with red globules."‡ The mode of production of these globules, as well as those of the chyle, is also undecided; but Müller says that "they must either be thrown off by the particles of the organs in absorption, or be formed in the lymph itself."§

The chyle and lymph when poured into the blood become assimilated to it probably in the respiratory organ, at least it is only after the blood has been exposed to the action of the air that it exhibits any change of appearance in its conversion from dark red to scarlet; and this is the only alteration of which we can obtain any actual cognizance, although some very important change in its condition must take place, as is proved by its being refitted to support the vital functions, which as dark coloured blood it was unable to sustain. It would seem probable that the lymph, which having already made the round of the circulation must have thereby been fully animalized, undergoes here less change than the chyle which has never been circulated through the body, or exposed to the action of the air, and therefore requires to be exposed to atmospheric influence before it become fitted for employment in the nutritive functions of the body. But the most complete ignorance of the formation of the blood globules prevails; whether the chyle and lymph globules become the nuclei of the blood globules, the former however from their greater size being less likely to be so than the latter, whilst the latter from their smaller number can scarcely be considered sufficient for the purpose, is still matter of dispute; and even were it so admitted, the difficulty still remains as to where and how the nuclei obtain their envelope of colouring matter or hæmatosine, even though according to Emmert iron is contained in the chyle, and which from the observations of Engelhart* already adverted to appears to be the base of the colouring matter.

*Of the change which the blood undergoes in respiration.*—The important influence which respiration exerts over the blood was observed by the earliest writers on physiology, although their explanations of the mode in which it operated were extremely erroneous. Haller has in his *Elementa Physiologiæ* given an account of these theories, the principal of which have also been noticed by Priestley in his *Observations on Respiration and the Use of the Blood*. Even before Aristotle's time, it was held that the heat of the blood was tempered in the lungs. Galen imagined that a something equivalent to fire was kept up in the heart, and that the vapours thrown off from it were discharged by the lungs like smoke from fire: and even so late as Descartes, who still retained the notion of a vital fire in the heart, it was maintained that the air was necessary for cooling and condensing the blood. A more correct view of the matter, however, was subsequently taken by those who held that the air itself, or some part of it, was taken into the blood from the lungs, although their notions of the effects it produced were equally unsatisfactory: some supposing that it excited a fermentation, and others that it maintained the fluidity, motion, and heat of the blood by preventing the too close contact of the globules; whilst those who asserted that only a part of the air was absorbed, either held that some active spirituous and ethereal particles were derived from it, and supposed these were converted into animal spirits; or denying this, considered that a *vital principle* was acquired from it, either as a saline vapour, a volatile acid salt preventing fermentation, or an aerial acid protecting the blood from putrefaction, preserving its density, and strengthening the animal fibres. Whytt supposed there was something of a vital and stimulating nature derived from the air into the blood, by which it made the heart contract; whilst Boerhaave speaks of unchanged air being deadly, not on account of heat, rarefaction, or density, but for some other *occult cause*.

Lower, in† 1669, appears to be the first who held any correct views upon the change of blood from its venous to its arterial colour. He found on opening the chest of a living animal, that the right side of the heart contained purple or venous blood, which being propelled through the lungs whilst those organs were artificially inflated with fresh air, returned to the left side of the heart of a bright arterial colour; he therefore determined that the change took place in the capillary vessels of the lungs. And he also held that this change depended on the action of fresh air, because he found that if the same air were inflated repeatedly into the lungs, the blood came back to the left side of the heart of the same dark purple colour as when propelled into the lungs, which colour however it lost if fresh air were employed. His ideas on this point were further supported by the dark clot of venous blood when exposed

* Müller, p. 246.
† *Ibid.* p. 244.
‡ *Ibid.* p. 141.
§ *Ibid.* p. 248.

* See p. 117.
† His *Tractatus de Corde item de Motu et Colore Sanguinis, &c.*

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Zoology. to the air becoming bright red, just as when venous blood had been acted on by the air in the lungs.*

In 1674, Mayow published his Treatise *De Respiratione*, in which after confuting the several opinions previously held, and observing from experiment that frequently breathed air is unfit to support life, he concludes, "I therefore assert that from the inspired air something absolutely necessary for life is communicated to the blood, which being exhausted, whatever it may be, the air is rendered useless, and no longer fit for respiration."† And he thinks "it very probable that the lighter and nitrous particles with which the air abounds are those which are communicated by the lungs to the blood."‡

The observations of Cigna§ of Turin upon the effect of the air's action on the venous clot entirely corresponded with those of Lower, and he held that the air once breathed was unfit for further respiration, on no other account than its being loaded with noxious vapours, the presence of which was discovered by their fetid smell: but although he had in his first Memoir believed that the change of the blood's colour took place in the lungs, yet in the second he was disposed to doubt it. The experiments of Hewson corresponded with those of Lower and Cigna; and he observes, "as a similar change is produced by air applied to blood out of the body, it is presumed that the air in the lungs is the immediate cause of this change; but how it effects it is not yet determined."‖

In 1755, Dr. Black, in his paper entitled *Experiments upon Magnesia Alba, Quicklime, and some other Alcaline Substances*,¶ published his discovery of fixed air, "which is dispersed through the atmosphere, either in the shape of an exceedingly subtile powder, or more probably in that of an elastic fluid." And two years after he stated in his lectures that fixed air was "deadly to all animals that breath it by the mouth and nostrils together;" and a little further on he says, "I convinced myself that the changes produced on wholesome air by breathing it consisted chiefly, if not solely, in the conversion of part of it into fixed air."**

In 1772, Dr. Priestley published his *Observations on different Kinds of Air*, in which he suggested, "that one use of the lungs was to carry off a putrid effluvium;"†† and in 1776, in his *Observations on Respiration and the Use of the Blood*, he says, "What I then concluded to be the use of *respiration* in general, I have now, I think, proved to be effected by means of the *blood*, in consequence of its coming so nearly into contact with the air in the lungs, the blood appearing to be a fluid wonderfully formed to imbibe and part with that principle which the chemists call phlogiston, and changing its colour in consequence of being charged with it or being freed from it."‡‡ "The phlogiston with which the animal system abounds,"§§ he considers, is imbibed by the blood in the course of its circulation. And then after detailing several experiments upon the clot of venous blood, by which he proved that black blood exposed to pure or dephlogisticated air resumed its red colour, but at the same time produced the constant effect of phlogiston in depraving the air, he concludes "that this black blood must have communicated phlogiston to the air, and consequently its change from black to a florid red must have been occasioned by the separation of phlogiston from it."* Zoology.

In the following year, 1777, Lavoisier observed in one of his papers "that respiration acts only on a portion of the pure air, or that which is specially respirable, that the surplus or mephitic part is purely passive, inspired and expired without change, and that animals perish when they have absorbed or converted the greater part of the respirable air into aeriform acid of chalk."† He thus confirmed Black's notion of the conversion of a part of the atmospheric into fixed air, and it would seem more probable that he became aware of the fact by his own observation, rather than from having borrowed it, as Dr. Bostock seems to imply, without acknowledgment from Black, whose opinion on this point, although expressed in his thesis in 1756, did not probably attract attention till the publication of his lectures by Dr. Robinson in 1803. In the same paper also Lavoisier proved the incorrectness of Priestley's observation, that "the blood, like the calcination of metals and other chemical processes, phlogisticates the air;" showing that whilst in the latter the dephlogisticated air combined with the metal and generated no other gas, the effect of the blood was not only to deprive the air of its dephlogisticated part, but at the same time to produce a corresponding quantity of fixed air, which could be shown by its rendering lime water turbid, and when removed by lime or caustic potash left the mephitic air the same in both cases.‡

In 1788, Crawford published the second edition of his *Experiments and Observations on Animal Heat, &c.*; in which having observed that inflammable air introduced into the veins of a living animal increased the livid colour of the blood, and that arterial blood underwent the same change of colour in the capillaries, he determined that "the absorption of inflammable air or its basis is the cause of the change" there taking place; whilst on the other hand, "when the blood again recovers its florid colour in the lungs, the inflammable principle is detached," the pure air received into the lungs combining "with a portion of the inflammable air contained in the venous blood."§ This inflammable air he describes as of two kinds, the second of which burns with a lambent flame,‖ and leaves as its residuum fixed air. This kind of air he considers to be united with the blood in the capillaries, "and" he proceeds to say, "since it is found that fixed air is exhaled by expiration, a portion of the pure air being at the same time made to disappear, there is I think the utmost reason to believe, that the fixed air which is the result of this process is produced by the union of the pure and inflammable air which come into contact with each other in the lungs."¶ And he subsequently adds, that a portion of the inflammable combines with a portion of pure air, and produces the aqueous vapour also exhaled from the lungs. The whole of this latter process, by which the blood also recovers its arterial colour, he conceives to be performed in the lungs, but that there is not any absorption of air into the blood, as by some believed, and that in the production of fixed air and aqueous vapour the atmospheric air "must necessarily

* Lower, *loc. cit.* p. 164—171.
† P. 21. ‡ P. 23.
§ *Miscellanea Taurica.* vol. v. p. 30.
‖ Hewson, *Experimental Enquiries into the Properties of the Blood*, p. 9.
¶ *Essays and Observations Physical and Literary*, vol. ii. p. 218.
** P. 87.
†† *Philosophical Transactions*, vol. lxii. p. 187.
‡‡ *Ibid.* vol. lxvi. p. 227. §§ *Ibid.* p. 238.

* *Ibid.* p. 242.
† *Mémoires de l'Académie Royale des Sciences*, 1777, p. 193.
‡ *Ibid.* § Crawford, p. 151. ‖ *Ibid.* p. 152. ¶ *Ibid.* p. 153.

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give off a considerable portion of its absolute heat in the lungs,"* which being there absorbed by the blood is subsequently given out by it in its passage through the capillaries, where the blood "is again impregnated with the inflammable principle, in consequence of which its capacity for heat is diminished,"† and thus as the blood is continually imbibing the inflammable principle from the body, and emitting heat which it had acquired by the formation of the fixed air in the lungs, the heat is diffused over the whole system.

In the year 1787 was read before the Royal Academy of Science at Paris the paper entitled *Méthode de Nomenclature Chimique proposée par MM. de Morveau Lavoisier, Berthollet, et de Fourcroy*, which was their joint production, and speedily put aside the vague and incorrect names applied to chemical substances, and more particularly to the different kinds of air. The section relating to the nomenclature of the airs or gases is written by De Morveau, who speaks of them as four different kinds. 1. *Oxygen*,‡ (from the Greek ὀξυς, *acid*, and γεινομαι, *I produce*,) a name for some time previously applied by Lavoisier to the principle or base of dephlogisticated or vital air, on account of its very constant property of converting a number of substances with which it unites into a state of acid, or rather because it appears to be a necessary principle of acidity: it is that part of vital air which supports respiration and combustion. 2. *Hydrogen*,§ (from ὑδωρ, *water*, and γεινομαι,) previously but incorrectly called inflammable air, as other gases besides it are capable of inflaming; but its name is given as the fixed principle or base of water. 3. *Azote*‖ (from α privative, ζωη, *life*) was the phlogistic air of some, and the mephitic air of other chemists; that name is applied to it on account of it being incapable of supporting life. It forms a considerable portion of atmospheric air, (seventy-nine parts in one hundred, the remainder being oxygen,) and is not as formerly supposed vital air in an altered state, with which it has nothing in common except its gaseous form. In consequence of its existence in volatile alkali, Fourcroy proposed calling it *Alkaligen*. But the experiments of Cavendish having shown that one of its most important properties is the union of its base with oxygen to form nitric acid, it is more commonly called *Nitrogen* by chemists. 4. *Carbonic Acid*¶ is produced by the union of carbon, the pure essential principle of charcoal, with oxygen. It has borne many names; by its discoverer Black it was called *Fixed Air*, from being found in a condensed state in some of the alkalies and earths; Bergman applied to it the term *Aerial Acid*, and the French chemists *acide crayeux aëriforme*; but it is now universally known as Carbonic Acid.

In consequence of this complete change in the chemical nomenclature, a student is often much troubled to comprehend the meaning of the terms originally employed by the writers on the change of the blood during respiration up to the period referred to, and it will not therefore be out of place to recapitulate briefly in modern language those which have been already quoted on this subject. Black discovered the production of carbonic acid in air which had been breathed. Priestley, showing that arterial blood became black when exposed to carbonic acid, hydrogen, nitrogen, and air which had been breathed, (the latter being according to his view loaded with phlogiston which vitiated it,) but that when transferred into common air or into oxygen it recovered its bright red colour, held that the latter change corresponded with the change of the air taking place in the calcination of metals, in which the oxygen is abstracted. Lavoisier, however, showed that the experiments of Priestley were incorrect, inasmuch as that, in the blood's action upon the atmospheric air or oxygen, carbonic acid was produced, which did not occur in the calcination of metals. Crawford, finding that blood was darkened by hydrogen, considered that in the course of circulation this gas, or rather carburetted hydrogen, (that second kind of which he speaks as leaving fixed air after combustion,) being absorbed was the cause of the dark colour, and that blood so impregnated when brought to the lungs and exposed to atmospheric air, gave off this carburetted hydrogen, one portion of which uniting with the oxygen of the air formed carbonic acid, whilst the remaining part also uniting with oxygen formed water, which together with the carbonic acid was also expired from the lungs. He denied the absorption of any pure air or oxygen into the blood whilst passing through the lungs, but he held that during the combination just mentioned heat was generated in the lungs by which the blood was warmed, and thus by the circulation of the blood the due animal temperature was preserved throughout the body.

In 1791, Hassenfratz, in a paper *Sur la combinaison de l'oxigène avec le carbone et l'hydrogène du sang, sur la dissolution de l'oxigène dans le sang, et sur la manière dont le calorique se dégage*,* combated Crawford's opinion with reference to the non-absorption of oxygen, and after quoting Girtanner's observation, that "during respiration a part of the oxygen of the vital air combines with the venous blood, the deep colour of which it changes and renders it vermilion,"† proceeds to examine Lagrange's view of the subject, who "supposed that the blood in passing into the lungs dissolved the oxygen of the respired air, that this oxygen in a state of solution was conveyed by the blood into the arteries, and thence into the veins; that in this course the oxygen gradually quitted its state of solution to combine partly with the carbon and hydrogen of the blood to form water and carbonic acid, which are set free from the blood so soon as the venous blood passes from the heart into the lungs;"‡ and the result of his inquiries led him also to believe that "the black colour of the blood results from the intimate combination of the oxygen gas with the carbon and hydrogen of the blood, whilst its red colour merely arises from the solution of the oxygen gas in the blood:"§ whilst at the same time he accounts for the fact observed by Fourcroy of the intensity of the vermilion colour of blood continually in contact with oxygen, "by the diminution of the affinity of the blood for oxygen, in proportion as its carbon and hydrogen are combined with the (oxygen) gas with which it was previously impregnated."‖

The opinion advanced by Sir Humphry Davy¶ in 1800, differed only from that of La Grange and Hassenfratz in supposing "that the whole compound atmospheric

* *Ibid.* p. 355. † *Ibid.* p. 362.
‡ P. 32. § P. 33.
‖ P. 34 ¶ P. 43.

* *Annales de Chimie*, vol. viii. 1791.
† *Loc. cit.* p. 264.
‡ *Ibid.* p. 266. § *Ibid.* p. 270.
‖ *Ibid.* p. 272.
¶ *Researches Chemical and Philosophical, chiefly concerning Nitrous Oxide or Dephlogisticated Nitrous Air and its Respiration*, p. 447.

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air passes through the moist coats of the vessels," and that in them the change of the blood actually takes place. He held that the air thus received into the vessels "is first dissolved by the serum of the venous blood, and in its condensed state decomposed by the affinity of the red particles for its oxygene," all of which "is consumed, *apparently* a small portion of the nitrogene lost, and a considerable quantity of carbonic acid produced." He also adds, that "from the experiments on the respiration of nitrous oxide and hydrogene, it appears that a certain portion of the carbonic acid produced in respiration is evolved from the venous blood:" and "supposing that no part of the water evolved in solution by the expired gas of common air is formed immediately in respiration, it will follow that a very considerable quantity of oxygene must be constantly *combined* with the red particles, even allowing the consumption of a certain portion of it to form carbonic acid; for the carbonic acid evolved rarely amounts to more than three-fourths of the volume of the oxygene consumed."* These notions of the evolution of carbonic acid from venous blood, and the combination of a very considerable quantity of oxygen combined with the red particles were published by Davy in 1800, and their correctness has within the last few years been fully established; for in 1834, Bertuch obtained carbonic acid by passing hydrogen through venous blood, and the same has been since done by Magnus, Müller, and others; whilst in reference to the second, the experiments of Magnus† have proved the existence of oxygen in the blood, and that in arterial blood it equals at least one-third, and occasionally one-half the quantity of carbonic acid therein contained, whilst in venous it equals only one-fifth or one-fourth; and though it has not been positively proved that either oxygen or carbonic acid are specially connected with the red globules, yet, as will be presently noticed, it is more than probable that such is the case.

The experiments of Magnus are further important as proving that not only oxygen and carbonic acid, but also nitrogen, are contained in the blood, the average total of which amounted to one-tenth, and sometimes one-eighth of the whole volume experimented on; "this however," he observes, "is evidently but a small part of the air contained in the blood."‡ As to the relative proportion of the gases themselves, in arterial blood the oxygen equals at least one-third, and almost one-half, and the nitrogen nearly one-fifth of the contained carbonic acid, whilst in venous blood the oxygen equals at most only one-fourth, and often only one-fifth of the carbonic acid there found, the nitrogen remaining in nearly the same proportions in both kinds of blood.

These gases are not in their aeriform state in the blood, but are in solution, as are hydrogen and nitrogen in water, nor does the blood thus impregnated give them out till brought into contact with another gas, when an interchange takes place till the two gases are completely mixed. And thus is explained the chemical change occurring in respiration, the carbonic acid of the venous blood is partially extracted from it (for a portion still remains) by the atmospheric air with which it comes in contact, whilst at the same time the blood acquires oxygen, which in the course of the arterial circulation disappears, and carbonic acid is again formed, so that venous always contains more carbonic acid than arterial blood.

With regard to the source from whence the carbon of the blood is derived, there cannot be any doubt that it is largely supplied from the chyle, but it is also generally held, that part of it is obtained from the body itself. The latter statement, however, is denied by Dr. Murray, who says, that "carbon appears to enter in smaller proportions into the composition of animal than of vegetable matter;" (which is well known:) "in the expenditure of the elements of the blood, therefore, in the extreme vessels forming the animal solids and fluids, carbon will be left redundant, and this appears to constitute the *conversion of arterial into venous blood.* In respiration the oxygen of the inspired air acting on the extensive surface of the blood circulating through the lungs will abstract a portion of carbon, forming carbonic acid; and this gives rise to the *conversion to the arterial state.* The accumulation of carbon is thus prevented, and the due proportion of the elements of the blood preserved."* This explanation cannot be admitted, when, as appears from Dr. Fyfe's experiments, the quantity of carbonic acid is materially diminished by a vegetable diet, under which circumstances, if Murray's theory were correct, it ought to be much increased.

As might naturally be expected from the great importance of respiration to the blood, inquiries have been made as to the daily consumption of atmospheric air in that process. The capacity of the lungs has been estimated by Dr. Bostock† at 290 cubic inches in their quiescent, and at 330 cubic inches in their distended state; and the quantity of air received at every single natural inspiration amounts according to Jurin and Menzies to 40 cubic inches; the air changed therefore at each natural respiration is about one-eighth, or by a violent expiration two-thirds of the whole quantity contained in the lungs. If then 40 cubic inches be multiplied by 20, the average number of inspirations in a minute, 800 cubic inches will be breathed every minute, 48,000 every hour, and 1,152,000 cubic inches, or 666⅔ cubic feet every day, to which the blood passing through the lungs, computed at 10 pounds in a minute, is exposed. From this quantity of air Bostock states, that 45,000 cubic inches or nearly 15,500 grains of oxygen are consumed, and the quantity of carbonic acid produced at 40,000 cubic inches, or 18,600 grains, that is, nearly three pounds, containing 5,208 grains of charcoal, and 13,392 grains of oxygen, so that there is a surplus of oxygen more than necessary for the production of the carbonic acid. But the quantity of carbonic acid discharged is not the same at all times, for Dr. Prout‡ has observed, that most is given off between eleven A. M. and one P. M., from which time it gradually diminishes to eight and a half P. M., and continues stationary till three and a half A. M., after which its quantity again gradually increases. He further remarks, that should this evolution be increased or diminished above the usual maximum or minimum, there will be an inverse diminution or increase in an equal proportion in the subsequent period. And he also found that though many circumstances, as long and violent exercise, fasting, the use of vinous or spirituous liquors, perhaps sleep, and certainly depressing passions and violent emotions, would diminish the quan-

* Davy, *loc. cit.* p. 448.
† *Ueber die im Blute enthaltenen Gase, Sauerstoff, Stickstoff und Kohlensäure*, in Poggendorff's *Annalen*, p. 583.
‡ Magnus, *loc. cit.* p. 600.

* *Elements of Chemistry*, 4th Ed. vol. ii. p. 455.
† *Elementary System of Physiology*, vol. ii. p. 34.
‡ Thomson's *Annals of Philosophy*, vol. ii. p. 328; vol. iv. p. 331.

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tity of carbonic acid produced, yet very few increased it, and only in a slight degree. The experiments of Dr. Fyfe* also showed the effect of substances taken into the stomach upon the evolution of carbonic acid, which was much diminished by wine, to nearly half by vegetable diet, and to nearly one-third by a course of mercury.

Admitting that the venous blood is brought to the lungs loaded with carbonic acid which is there discharged, and in its place oxygen is absorbed, it becomes a question whether the whole mass of the blood is equally impregnated with the oxygen? Mr. Hunter thought, that "most probably the effect of air upon the blood is greatest on the coagulating lymph"† or fibrine. Whether this is the case is not yet determined. But the experiments of Berzelius prove that the serum is not much concerned in the matter, as it absorbs only a very small quantity of oxygen. This observation has been since confirmed by De Maack,‡ who has further shown that the red colouring matter is the principal absorbent, as a solution of it to the amount of two and a half volumes abstracted from two volumes of oxygen one and a half of that gas. He therefore presumes that the colouring matter impregnated with carbon becomes oxydized by respiration, whilst at the same time the carbonic acid is set free.

The serum has however probably something to do with the change in the colour of the blood by the action of the salts which it contains, for Dr. Stevens has shown by experiments, confirmed by Dr. Turner, that if the clot of arterial or venous blood be washed in water so as to free it entirely from the serum, it becomes of a dark colour, and cannot be rendered florid by exposure to oxygen until immersed in serum, or in a solution of sea salt or bicarbonate of soda; he therefore supposes that by the removal of the carbonic acid, to which he ascribes the dark colour, the influence of the salts of the serum is restored, and the bright arterial colour recovered, without the influence of the oxygen further than that of removing the carbon. De Maack, however, states that the colouring matter of both arterial and venous blood remains blackish until brought into contact with neutral salts, in which case the oxygenated blood assumes the florid arterial, and the carbonized blood the deep venous hue. The change of colour therefore from venous to arterial cannot be assigned to the action of the salts.

The theory of respiration advanced by Mitscherlich, Tiedemann, and Gmelin, seems to agree with Stevens's observations on the colour of the blood just mentioned. They state that acetic or lactic acid exists in the blood, and most other animal secretions, free or combined with an alkali, and that it is excreted by the urine and sweat so largely, that it cannot be supposed to be taken in with the food, and must therefore be formed in the body. They consider it is produced by the action of the oxygen upon the blood in the lungs under favourable conditions, the air permeating the coats of the vessels, and coming into immediate contact with the blood, part of the oxygen uniting directly with the carbon and hydrogen to produce carbonic acid and vapour, whilst another part combines with some of the organic constituents of the blood. Hence are formed new products, of which lactic or acetic acid is the principal, which, decomposing part of the carbonate of soda, sets free its carbonic acid which is expired, and the acetate of soda thus formed in the lungs being subsequently deprived by various secretions, especially the urine and sweat, of its acetic acid, the remaining alkali again combines with the carbonic acid produced by the further decomposition of the organic constituents of the blood during its circulation, and again is brought to the lungs as carbonate of soda.*

It may not be improper here to observe that, generally speaking, an animal confined in a given quantity of air does not consume the whole of the oxygen therein contained before it dies, and therefore that it is destroyed not by the want of oxygen, but by the presence of the deleterious carbonic acid which has been evolved during respiration. This circumstance was proved by Lavoisier, who found that by abstracting the carbonic acid as fast as it was formed by means of caustic potash, a guinea-pig could live in an atmosphere the oxygen of which had been reduced to 6·66 per cent.

It is also to be observed, that all animals do not alike deprive the air of its oxygen, in the higher classes of which the cells of the lungs are most minutely divided, and consequently more oxygen required; this is not more completely extracted from the air breathed than in the lower classes which require less oxygen, but just the contrary; for birds in which the blood is most perfectly aerated abstract less than any other animals, whilst on the other hand in those in which the aeration is comparatively imperfect, more oxygen is abstracted, and according to Vauquelin, the air is completely deoxydised by some species of *Helix* and *Limax*;† Spallanzani‡ has also observed the same fact in relation to several kinds of worms. It follows, therefore, that if the higher animals do not so completely deoxydize the air as the lower, although at the same time their well-being requires more oxygen, this can only be compensated by the more frequent inspiration of atmospheric air, and hence originates the cause of the more frequent and necessary respiration of the higher classes of animals.

*Difference between arterial and venous blood.*—After what has just been observed, it remains only to state that although the blood has generally the same character and composition throughout the body, yet as it flows through the arteries it possesses certainly peculiarities which it loses, and acquires others as it passes through the veins. Of these the most striking is colour; for whilst arterial blood is bright scarlet, at least in those classes of animals in which it is most perfectly aerated as in those of beasts and birds, venous blood on the contrary is distinguished by its deep Modena red colour, which it acquires in the extremely minute divisions or capillary branches of the vascular system, where are given off the nutritive and vital properties of the blood; which being thus vitiated and passing into the veins, there also receives those materials of the body which, having become useless or noxious to the animal economy, require to be carried away and discharged from the body by respiration or other excretory process. This difference of colour, as already mentioned, depends upon the greater quantity of carbon present in venous than in arterial blood; and in the larger quantity of oxygen in arterial than in venous

* *Inaugural Dissertation*, 1814.

† Hunter, *loc. cit.* p. 51.

‡ *De ratione quæ colorem sanguinis inter et respirationis functionem intercedit.*

* In Tiedemann's *Zeitschrift für Physiologie*, vol. v.

† *Annales de Chimie*, vol. xii. p. 238.

‡ *Memoirs on Respiration*, (transl.) p. 68.

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Zoology. blood. The specific gravity of both kinds of blood is nearly the same; that of arterial being 1047, and of venous 1050, according to Dr. John Davy. Nor is there much difference in their temperature; for whilst Davy considers arterial blood only 1° to 1½° Fahrenheit higher than venous, other chemists have denied there is any difference.

A very important distinction, however, between the two kinds of blood is the quantity of fibrine which they contain, and consequently the relative quickness and solidity with which they coagulate. More fibrine is contained in arterial than in venous blood, and according to the experiments of Müller on goat's blood, in the proportion of 29 to 24.* It is on this account that the arterial clot is more firm, and that more serum is yielded by arterial blood, the fibrine contracting more strongly and squeezing it out more completely. The different quantity of fibrine in the two kinds of blood Müller accounts for by observing that the lymph which contains a large quantity of fibrine, conveys it through the thoracic duct into the venous blood only just prior to the passage of that blood through the lungs; whence having been aerated, it pours forth again into the arterial circulation reloaded with fibrine, which in the capillary vessels it discharges for the nourishment of the tissues, and as venous blood again has less fibrine than when arterial. Hence, when coagulation takes place, the venous clot is less firm; because it not only contains less fibrine, but that the fibrine is more separated. The production of the fibrine seems to be also in some way affected by respiration; for it has been not only observed that little fibrine, (indeed some physiologists say none,) is contained in fœtal blood, but also in persons the auricles of whose heart are imperfectly separated, and the venous and arterial blood consequently mixed, that the blood is indisposed to coagulate perfectly.

*Vitality of the blood.*—To Mr. Hunter is the merit due of having first insisted upon this important property of the blood, all previous physiologists having restricted vitality to the solids alone. "To conceive," says he, "that blood is endowed with life, while circulating, is perhaps carrying the imagination as far as it well can go; but the difficulty arises merely from its being fluid, the mind not being accustomed to the idea of a living fluid."† But if, as Müller has well observed, "whatever in the organism exhibits actions of a different kind from those springing out of inorganic laws, has an organic, or what is the same, a vital property," and as "the blood exhibits organic peculiarities, is affected by living and irritable parts, and there is a living mutual operation between the blood and organized parts in which the blood participates as completely as the organ itself * * *. The blood has therefore vital properties which also belong to all animal juices, excepting those which carry off the effete parts, as the urine and carbonic acid."‡ This opinion of Müller's as to the mutual operation between the blood and organized parts bears a close resemblance to, if it have not originated in, Mr. Hunter's subsequent observation, that "the blood has as much *materia vitæ* as the solids, which keep up that harmony between them; and as every part endued with this principle has a sympathetic affection upon simple contact, so as to affect each other, (which I have called *contiguous sympathy*,) so the blood and the body are capable of affecting, and being affected, by each other, which accounts for that reciprocal influence which each has on the other."*

The vitality of the blood, however though formerly disputed, is now pretty generally held, for "when all the circumstances attending this fluid are fully considered, the idea," says Mr. Hunter, "that it has life within itself may not appear so difficult to comprehend; and indeed when once conceived, I do not see how it is possible we should think it to be otherwise; when we consider, that every part is formed from the blood, that we grow out of it, and if it has not life previous to this operation, it must then acquire it in the act of forming."† But he subsequently observes, "It is probably impossible to say where the living principle first begins in the blood; whether in the chyle itself or not till that fluid mixes with the other blood and receives its influence from the lungs. I am however rather inclined to think that the chyle is itself alive."‡

Admitting then the vitality of the blood, it becomes a question whether either or which of its component parts is more especially concerned in the support of animal life? Upon this point physiologists have held different opinions.

It was considered by Mr. Hunter, that "the coagulating lymph (fibrine) being common probably to all animals, while the red particles are not, we must suppose it, from this alone, to be the most essential part; and as we find it capable of undergoing, in certain circumstances, spontaneous changes which are necessary to the growth, continuance, and preservation of the animal; while to the other parts we cannot assign any such uses, we have still more reason to suppose it the most essential part of the blood in every animal."§ And he subsequently further remarks of the globules, that "they certainly are not of such universal use as the coagulating lymph, since they are not to be found in all animals, nor so early in those that have them, nor are they pushed into the extreme arteries, where we must suppose the coagulating lymph reaches; neither do they appear to be so readily formed. This being the case, we must conclude them not to be the important part of the blood in contributing to growth, repair, &c. Their use would seem to be connected with strength; for the stronger the animal, the more it has of the red globules, and the strength acquired by exercise increases their proportion."‖

If these opinions of Mr. Hunter be examined carefully, it will be seen that they are less correct and comprehensive than is usual with him; for there can be no doubt that the albumen is equally important with the fibrine, the former being required for the building up of the bony and membranous parts, as well as other organs which might be mentioned, as the latter is in the formation of muscles; and therefore of these two components, one cannot be allowed to be more important than the other in the animal economy. But neither are these to be considered more essential than the globules: Mr. Hunter's assertion that they are not "pushed into the extreme arteries" is incorrect, for according to the observations of Müller they are found "in the most delicate capillary vessels which are not red, nor even yellow, but completely transparent,"¶ although instead

* Müller, *loc. cit.* p. 307. † Hunter, *loc. cit.* p. 77. ‡ Müller, *loc. cit.* p. 141.

* Hunter, *loc. cit.* p. 89. † *Ibid.* p. 78. ‡ *Ibid.* p. 91. § *Ibid.* p. 28. ‖ *Ibid.* p. 46. ¶ Müller, *loc. cit.* p. 210.

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of being numerous they follow each other in a single row and at unequal distances; the same occurs also even in the so called *serous* vessels, and is admitted by Wedemeyer. That one of their uses (the only one however allowed by Mr. Hunter) is connected with strength is certainly true, as it is well known that animals which have been purposely bled for whitening their flesh, as calves for instance, and persons who have been subjected to severe bleeding, have the number of their red globules considerably diminished, and have proportionate loss of muscular power, which is only slowly recovered as the red globules are very gradually produced. But it cannot for a moment be supposed that the support of muscular strength is the only or principal use of the globules, neither can it be imagined that such could really have been Mr. Hunter's meaning, although he was unacquainted with the recent discoveries which seem reasonably to assign a very important office to the globules, viz. that of supporting the *vital energy* by transmitting to the different parts of the body the vital influence of the atmosphere. The importance of the globules, at least in those animals in which they are red, might naturally be assumed from the fact, that whatever changes the blood may undergo during respiration, the globules are the only one of its parts which exhibit any alteration in character; they come to the respiratory organ of a dark red colour, and they leave it of a bright scarlet; they pass through the arteries of a bright scarlet, but when first found in the most minute veins are deep red; and these two changes are effected in the short space of three minutes, the time occupied in each circuit of the blood, *i. e.* the double change of colour, being effected 480 times in every twenty-four hours.[*] It cannot, therefore, be considered that agents thus remarkably affected can perform a minor part in the economy of the blood.

The experiments which have been of late years made in reference to the important subject of Transfusion have thrown considerable light upon the relative importance of the several parts of the blood in supporting life. Prevost and Dumas found that neither pure serum nor warm water at a temperature of 68° of Fahrenheit, injected into the veins of an animal which had been bled to fainting, was capable of restoring life; and Dieffenbach proved that an injection of fibrine most minutely divided and in water was not more efficient. But the former experimenters observed that fluid blood if injected into the veins of an animal of the same species restored life; and even, as appeared by other experiments of Dieffenbach, although such blood had been deprived of its fibrine by beating it with a stick during coagulation, leaving the red globules floating in the serum. If then, as it would seem from these observations, revivification is not effected by the injection of pure serum, or of fibrine dissolved in water, but that on the contrary the animal is restored when either the whole mass of the blood, in which of course are contained the globules, or blood deprived of its fibrine only is injected, it is natural to infer that to the globules belongs this important property. This restorative power of the globules seems, however, to belong to them only in relation to animals of their own class, and perhaps even to a still more restricted group of animals. The blood of beasts deprived of its fibrine and injected into the veins of birds causes death in a few seconds, with strong convulsive symptoms similar to those excited by poison. And this cannot result from any mechanical obstruction to the flow of blood through the small vessels, because the globules of the blood of beasts are smaller than those of birds; the dangerous consequences therefore which ensue on their injection must depend upon some other cause.

Upon this subject Bischoff gave a very interesting paper,[*] entitled *Beiträge zur Lehre von dem Blute und der Transfusion desselben*; and repeating for his own satisfaction the experiments of Prevost and Dumas, and those of Dieffenbach, he was surprised to find that his results did not correspond with theirs; for in his first three experiments,[†] having injected the blood of a calf deprived of its fibrine into the veins of fowls, the animals were not inconvenienced by it, as would seem, beyond the fright of the operation: in all these cases but little blood had been taken from the fowls before the operation. In the two following experiments,[‡] which were made with dog's blood deprived of its fibrine, neither bird was damaged, although in the one the fowl lost much blood, though less than injected; and in the other the duck had considerably more thrown in than she had lost. In the sixth experiment,[§] having opened the carotid artery of a dog and taken away some ounces of blood, he injected into its upper end towards the head half an ounce of fowl's blood from which the fibrine had been removed by beating with a stick; but as no reaction ensued, (he does not, however, state that the dog was bled to fainting or not, but probably not, for he mentions that after the operation the animal fainted, as he supposes, from having struggled and suffered much,) he threw an ounce of fowl's blood into the jugular vein; the dog then gradually recovered, and in a fortnight was perfectly well. He then repeated the experiments of Prevost and Dumas, and those of Dieffenbach, injecting fresh unbeaten blood of a kitten in one instance, and of a rabbit in another, into the veins of fowls, and with the same result; in both cases the birds became violently convulsed, and died in a few seconds as if they had taken strong poison.

In neither of the foregoing experiments, however, had the animals which were transfused been bled to fainting; and it was therefore necessary to institute further inquiries as to the extreme state in which blood might be injected with effect. With this view Bischoff bled a duck from the jugular vein till it fainted; then having separated the fibrine from the blood by beating, he slowly injected the serum and globules, and the animal revived; he again drew off the blood till the duck seemed quite dead, and after again abstracting the fibrine, reinjected the serum and globules, and the duck again revived, but was very weak; it fed in the course of two hours and subsequently recovered, although pretty nearly all the fibrine of its blood must have been removed.[||] This settled the point as to the capability of beaten blood to restore an animal of the same kind even when apparently dead from loss of blood. Not so, however, when the beaten blood of one class was injected into the vessels of an apparently dead animal from haemorrhage belonging to another. A duck and a dog were both bled till they seemed to be dead; the beaten

* Muller, *loc. cit.* p. 343.

* In Müller's *Archiv fur Anatomie, Physiologie, &c.* 1835, p. 347

† *Loc. cit.* p. 350.

‡ *Ibid.* p. 351.

§ *Ibid.* p. 352

|| *Ibid.* p. 354.

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Zoology. blood of the dog was injected into the duck, and the beaten blood of three ducks was injected into the dog, but neither duck nor dog was restored. In another experiment a goose, which had been bled to seeming death, was injected with the beaten blood of two rabbits, but neither in this case was there any revival.*

The principal conclusions to be drawn from these experiments are, that the blood of one class of animals injected into another class is destructive of life, unless deprived of its fibrine; yet even when so conditioned, is not capable of revivifying if the animal has lost so much blood as to render it apparently dead; but on the contrary, that the blood deprived of its fibrine is capable of restoring again and again an animal of its own kind even when in an extreme state of fainting. Hence Bischoff infers that "that property of the blood of beasts which renders it deadly when injected into birds, must depend upon some *immaterial principle* as no mechanical influence can here operate; first, because the globules of beasts are smaller than those of birds; secondly, the globules in blood deprived of its fibrine have no such effect." He therefore considers this deadly principle to be "a specific property of the blood entirely distinct from its vital power, as the former is lost by beating the blood, whilst the latter is continued for a long time (thirty hours) after;"† that "it preserves the fibrine in a state of solution in the vessels, upon the abstraction of it depends the coagulation of the fibrine and the specific character of the class of an animal, and that its operation upon animals of another class is deadly."‡ Whether this peculiar principle is identical with the *halitus sanguinis* as held by some physiologists, who have shown that it exhibits specific differences in animals of different classes, in animals of the same class, and even in man, he does not offer to decide; but observes at the same time, that coagulation proceeds equally well in vessels hermetically sealed, and he might have added, even in the vessels of the body as observed by Hunter, in which cases there could not be any evaporation of the halitus.

That the globules themselves are not injurious when conveyed into the circulation of other animals even of different classes seems to be proved by the experiments of Magendie;§ for he injected the blood of quadrupeds into birds, and of frogs into quadrupeds, without injury, and in a very short time the oval globules of the bird or reptile disappeared in the blood of the beast; a "decisive proof of the important part of the process of assimilation which goes on within the blood-vessels," as Alison observes.‖

If then it be inferred from these observations and experiments that the globules are materially concerned, if not indeed the actual agents, in supporting the vital energy, (for it may be here added that the functions of the nervous system and animal life can alone be supported by arterial blood, although some of the functions of organic life, as the secretion of bile in the vertebrate classes generally, and of the urine in reptiles and fishes, are performed with venous blood,) the reciprocal action of the blood and of the parts through which it flows abstracting the vital principle from the one, whilst the useless or deleterious materials are transferred from the other, which appears to be proved by the alteration of the colour in the blood, considered to arise from its loss of oxygen and assumption of carbon in the general circulation, whilst in the respiratory organ the carbon is thrown off and the oxygen replaced, may not the globules serve as organs by which the vital properties of the air are transported through the body and distributed to the several parts, which are too distant or not themselves suited to abstract from the air its vivifying principle.

Kielmeyer, Treviranus, and other German physiologists, consider that the blood is endowed with a self-propelling power in the capillary vessels which still operates after the action of the heart has ceased, and is independent of it during life. This opinion is, however, denied by Wedemeyer and by Müller,* for two reasons: *first*, so long as the blood flows from the arteries of a limb which has been amputated, so long does it flow from the capillary vessels; and this continued for the space of ten minutes in an experiment in which the leg of a frog was amputated; these motions, however, depend only on the escape of the blood, in consequence of which their elasticity diminishes the size of the vessels which may be observed under the microscope; but if the limb be raised upright the flow of blood ceases in a short time, and in the course of five or six minutes all sign of motion in the capillary vessels ceases: *secondly*, if a moist amputated part be exposed to the sunshine, the surface soon dries and shrivels up, causing a speedy emptying of the capillary vessels, and as the sun shines through it, the flickering appearance is produced which lasts for many hours, but only at those points where the light for the moment penetrates; if, however, the shrivelled part be moistened, the flickering motion in the interior of the vessel ceases instantaneously, but recurs when the evaporation and drying of the part again begins; this phenomenon was reproduced even after thirty-six hours, by exposing the part to strong sunshine. Upon these grounds, then, there seems sufficient reason for denying the existence of any automatic motion in the blood itself.

*Use of the Blood.*—Whilst circulating through the body for the purpose of nutrition, or, as Mr. Hunter says, "to support the matter of the body," the blood also performs the no less important function of sustaining the vitality of its several organs; or, as the same writer expresses it, "of supporting the different actions of the body."† But in proportion as it executes these offices, its own vital powers are diminished, and it becomes incapable of supporting those actions until it has been again subjected to the influence of the air in the respiratory organs, by which its carbon is thrown off, and in its place oxygen is absorbed. The operation of the blood upon the performance of the animal and organic functions is very marked. For the sustenance of the former it is necessary that arterial blood should be supplied to the nervous system, the functions of which are interrupted and death caused by the circulation of venous blood, with symptoms resembling those produced by narcotic poisons. On the contrary, as regards the organic functions, though generally arterial blood is required, yet in some of them, as for example the production of the bile in man, beasts, and birds, and also of the urine in reptiles, the operation is performed with venous blood; the reason for which variation appears to be, that these fluids being the vehicles for discharging certain matters from the body which are injurious to it

* Bischoff, *loc. cit.* p. 354. † *Ibid.* p. 357.
‡ *Ibid.* p. 358. § *Leçons*, vol. iv. p. 365, &c.
‖ *Loc. cit.* p. 94.

* *Loc. cit.* p. 138. † Hunter, *loc. cit.* p. 93.



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If retained, the organs employed for their elimination belong to the excretory system of the body, and therefore the venous blood may as well discharge them in the liver and kidneys as it does the carbon in the lungs.

That the more perfectly arterialized, or more strictly speaking, the more perfectly aerated the blood is, so are the vital functions more actively carried on, is proved by the fact that in the two most active classes of animals, viz. birds and insects, the air is more freely admitted to their interior, in the latter especially, to almost every part of the body, and consequently brought in contact with the blood through the walls of the vessels distributed within the body; hence in birds the blood is of a brighter scarlet than in any other of the red-blooded classes. Whilst on the contrary in less active animals, as in reptiles, the surface offered by their lungs for the exposure of the blood to the action of the air is comparatively small, the lungs being often little more than bags, whose interior surface is overspread with a scanty network-like doubling; consequently the blood is little acted on by the atmosphere, its carbon but imperfectly discharged, its colour very dark, and the vital activity of such animals of a very low standard.

This difference, however, in the perfect aeration of the blood does not appear to interfere with the organic functions; nutrition and growth are alike performed by all classes through the operation of the capillary arteries, which may be said to be the manufacturers of the several fabrics composing the animal body, by separating from the blood the common nutriment of the body, such parts as they require for their several purposes, and compounding and moulding them into bone or muscle, cellular, arterial, or nervous tissue, as the wants of the general economy, or one or other of its parts, may need. All these processes are performed with arterial blood, which brings to the several parts the material to be used up. But venous blood differs materially, as it is the vehicle which receives the worn-out or hurtful substances either taken into the body with the food, or separated during the performance of the functions of nutrition and growth, and conveys them to those organs, as for instance, the respiratory, biliary, and urinary organs, by which they are excreted or discharged from the body.

In reference to the nutritive function of the blood, it may be here observed that Schultz* states that one use of the absorption of oxygen in respiration is to enable the *liquor sanguinis* to decompose the globules by attracting from them their nuclei, and thus rendering itself fitter for the nourishment of the different textures; and that the globules thus altered may be observed in the venous blood, specially in that of the portal circulation in the liver, thereby rendering it more fitted to throw off the bile. This subject he has pursued diligently with the microscope, but his opinions are as yet unsupported

### OF GENERATION OR REPRODUCTION.

Living bodies are distinguished from inorganic matter not merely by their power of constantly renewing the elementary particles which, in the aggregate, compose their organism, but of renewing the organism itself, the new creature being endowed with the same vital powers as the parent body from which it is the offset.

* *Instit.* 1838

This vital power of begetting life and reproducing living beings is designated Generation or Reproduction.



Much mystery has been attached to the function of generation, and it has been held to be more recondite, and more difficult of explanation or analysis, than the other operations of organic life. Such is not, however, truly the fact, for the generative function is quite as capable of being observed, and the attendant phenomena noted down, as those of nutrition; which is all that the physiologist can do in either case.

The more our observation is extended the more reason have we to admire the beautiful simplicity and wonderful uniformity of the operations of nature. We do not find one law ordained for the generation of men, another for the worm or the plant, but the same principle of action operating in all living beings. And however much the process may at first sight and from imperfect observation appear to vary, it has been found that the function of generation from the lowest to the highest resolves itself into this simple law—"that living matter has the power of so organizing and uniting together a greater or less portion of the elements of its own structure into such form as to render them capable in the aggregate of maintaining an independent existence when separated from the parent."

The phenomena which attend the growth of a germ, its separation from its parent, and the means provided for its nutrition and protection, are among the most interesting and curious in the science of Zoology.

Recent researches have shown that the first germ even of man himself, and the most simple form of vegetable life, is but a mere cell. This fact will be best understood by a reference to the discoveries of Schleiden regarding the developement of the tissues of plants.*

The fundamental or original matter from which the various tissues of plants are formed is gum, which, in the state immediately preceding the commencement of organization, is a consistent fluid, slightly wanting in transparency. The first step in the organizing process is the appearance of a number of extremely minute granules, most of which on account of their minuteness appear merely as black points; they increase rapidly in number, and thus the gum gradually becomes opaque.

Single, larger, more sharply defined granules are now evident in the mass, which soon afterwards present a regular form, and increase considerably in size, apparently from the coagulation of the minuter granules around the larger ones.

From these larger granules the cells take their origin; they appear to be the *first germs* of organization, and Schleiden proposes for them a name indicating their function,—*cyto-blast*, from κυτος, *cell*, βλαστος, *germ*.

They are now more usually entitled the *nuclei* of the cells, and, as will be perceived from further observations, they perform a very important part not merely in the developement of the varied *species* of animated beings, but even in the developement of each separate system of organs which in the aggregate constitute the being. "It was Robert Brown," says Schleiden, "who with his natural genius first conceived the importance of a phenomenon which, although observed previously by others, yet had been left totally unregarded."

"As soon as the *cytoblasts*," says Schleiden, "have

* See Schleiden, *Beiträge zur Phytogenesis* in Muller's *Archiv für Anat. et Physiol.* theil ii. 1838; also Taylor's *Scientific Memoirs*, vol. ii.

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attained their full size a delicate transparent vesicle rises upon their surface; this is the young cell, which at first represents a very flat segment of a sphere whose plain side is formed by the cytoblast, and the convex side by the young cell, which is situated on it somewhat like a watch-glass on a watch. In its natural medium it is distinguished almost by this circumstance alone, that the space between its convexity and the cytoblast is perfectly clear and transparent, and probably filled with an aqueous fluid, and is bounded by the surrounding mucous granules pressed back by its expansion.

"The vesicle gradually extends and becomes more consistent, and the covering now consists, with the exception of the cytoblast, which always forms one portion of the wall, of gelatine. The entire cell now gradually increases beyond the margin of the cytoblast and quickly becomes so large that at last the latter merely appears like a small body inclosed in one of the side walls. A proof of the close relation in which the cytoblast stands to the whole vital activity of the cell, that the small currents frequently covering the entire wall reticularly always proceed from it and return to it, and that in *statu integro* it is never situate without the current."*

And although the *cyto-blast* or nucleus is usually absorbed in the further developement of the tissues of the plant and the organs of the animal, still in many it remains during the whole period of existence. Its presence in the tissues of our own frames may be easily detected by the microscope in the nucleated scales of the epithelium, or in the ultimate filaments of muscular fibre, when by the action of acetic acid the filament is rendered transparent, leaving the nucleus or cytoblast as an opaque spot.

### *Reproduction of Vegetables.*

In some of the simplest forms of vegetable existence the individual species never rises above its simple embryonic condition as a nucleated cell. Some of the algæ and fungi are instances of this condition of vitality. Nevertheless they maintain their own existence, and are capable of reproducing their species. Each crimson vesicle which, collected in thousands, form the red snow, is itself an independent plant, *Protococcus nivalis*, has no connection with its fellow necessary for the preservation of its own integrity, and the continuance of its species is effected in a manner which, though simplicity itself, is not more simple than the first steps in the reproduction of the embryo of the mammalia, as will be seen hereafter. It is the subsequent and not the primary steps which make a distinction in the process as existing in the two creatures. Dr. Carpenter, in his interesting work on Physiology,† says, "Each vesicle of the *Protococcus* contains a number of little minute granules, which may be observed to increase within the parent cell, and at last to rupture the envelope and escape from its cavity. If their separation takes place in water, they are observed to have for some time a spontaneous motion in the fluid; and in their turn they develope themselves into new cells, which are burst asunder by the embryos contained within them.

"The same process will be found to take place in the highest plants, with this difference,—that as the whole system is *not* concerned in the formation of the embryo, but only a very small portion of it, that portion alone ceases to exist as soon as its function is performed, the life of the parent remaining uninjured."

It is only in the higher Cryptogamia that these portions of the organism, the reproductive cells, are distinct from the rest of the plant. When they are so, they are then called *spores*; the same parts in the Phanerogamia being designated *pollen*. Though it will not be possible in the confined limits of this Essay to trace the gradual perfection of the organs of reproduction in the vegetable kingdom, yet it is necessary to direct attention to the following details, as illustrative of the general phenomena which accompany the generative process in the simple sea-weeds, lichens, and mosses.

"In the higher algæ, where several cells unite together to form an individual, a certain separation of their functions takes place, some of the cells containing no reproductive granules or germs, and others evolving them abundantly. This may be noticed in the Confervoid tribes, and it is among them that the phenomenon of spontaneous motion is most obviously presented. The granules are first seen on the interior walls of the fertile cells as unformed green dots, which gradually assume a more definite aspect, and at last separate themselves from their attachment and move freely within the cell. After a period of continued restlessness one part of the containing cell is observed slightly to protrude, and in a short period to open in such a manner as to permit the exit of the granules. These move regularly for some time in the surrounding fluid, but at last they attach themselves, and commence their developement into new plants. The first change is one of form only, the granule becoming elongated into an oval. After a little time, the green matter which it contains is separated by a delicate partition, which subsequently becomes more decided, and by a succession of divisions and the increase of each cell thus formed a prolonged filament is produced. A precisely similar process takes place in many of the marine algæ, such as the *Ulva clathrata*, which has usually from three to six granules enclosed in each of the cells forming its frond; these escape by a pore, and exhibit a certain degree of spontaneous motion, although not so evidently as those of the Confervæ. Their early developement, however, follows exactly the same course; for the first change in the granules is manifested by their elongation into filaments, so that the young plant resembles a Conferva. Subsequently, however, these filaments present a double row of cells, and gradually increase in breadth, so as to form the foliaceous expansion peculiar to this tribe. The immediate cause of the movement of these reproductive granules has not been ascertained. They do not seem possessed of any thing resembling cilia, but Agardh imagines that they are propelled by the vibrations of a little beak or prolongation, with which they appear to be provided.*

"In the more complex organisms of this class we find a considerable specialization in the reproductive system, since, instead of the granules being liberated from the cells of the whole structure, a particular portion of the surface is appropriated to their formation, or even special external organs are evolved as receptacles for them."†

Many and curious are the steps by which nature has perfected the reproductive cells of these simple plants,

* See Taylor, *Scientific Memoirs, loc. cit.*

† *Principles of General and Comparative Physiology*, by W. B. Carpenter, M. D. p. 397.

* See Carpenter, p. 397. † *Ibid.* p. 393.



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but in this division of the vegetable kingdom physiologists have not yet discovered a second set of reproductive organs, such as we meet with in higher organisms, so that it would appear probable that reproduction can take place without the co-operation of two systems of organs, or of distinct parts of the same creature. In the Phanerogamia, the "organ for the production of vesicles containing germs" is, according to Dr. Carpenter, "the anther." From the anther is discharged the germ or pollen tube, which is conveyed through the pistil to the ovule residing in the ovarium at its base. "The changes which take place in the pollen-grain when it is brought in contact with the moist surface of the stigma, are exactly equivalent to those which have been described as occurring in the spore. The outer envelope separates in one or more points, and the inner tunic is protruded in the form of tubes, which contain some of the granules that might have been previously seen freely moving within their cell. These tubes insinuate themselves along the lax tissue of the style, and may be traced to the ovarium. There they enter the openings which up to that time have been left in the membranes of the ovules, in whose cavities nothing but a quantity of fecula and mucilaginous fluid previously existed; but one of the granules in the pollen tube thus introduced into each ovule gradually increases at the expense of these materials, and finally either occupies the whole ovulum by the absorption of the albumen into its cotyledons, or shares it with the separate albumen. The maturity of the seed is a period of cessation in its action, and it then arrives at a state of developement, in which it may remain dormant for a considerable period."*

### *Reproduction in Animals.*

The same principle seems to reign over the reproduction of animals which has been observed to exist in the vegetable kingdom, namely, that the offspring in the first instance is a growth from a portion of the parent. In the highest classes of animals it has been long known that such growth was not capable of maintaining an independent existence, unless it were brought into contact with a secretion from the organism of another creature. The individual producing and separating from its own organism the germ of the future being, is called the female, and its product an *ovum*, and the individual producing the vivifying fluid, is called the male, and its product the *semen*.

Further researches have shown that, even in the animal kingdom, organs endowed with the power of forming these two products, the *ovum* and the *seminal fluid*, may exist in the same individual. That the two sexes may be united in one person, constituting creatures called *Hermaphrodites*. The extent to which the more recent researches of Ehrenberg and others have shown that the two classes of organs exist throughout nature, and also the fact that many of the very simple forms of animated existence, previously supposed to consist of females alone, are in reality separable also into the two genders, make it almost doubtful whether the ova of animals are in any case perfected for independent existence by one set of organs, and whether, in those cases in which we can only observe female organs of generation, the male organs do not also exist, only in a form either too minute or otherwise obscured so as to escape our detection.

* Carpenter, p. 401.

The fact, that a true male seminal fluid is secreted in many of the *Acrita* where no especial organs have been detected for its production, has been established by the discovery of those curious, moving, animalcule-like bodies, called *Spermatozoa*. If the semen of the vertebrate division of the animal kingdom be examined with a microscope, thousands of actively moving little bodies, varying slightly in their form in different species, are found in it, and in all more or less resembling tadpoles in their general appearance. These bodies have been regarded as parasites, or *Entozoa* dwelling in the semen; but the universality of their presence forbids the idea being entertained, and it can no longer be doubted that they perform a most important and essential part in the function of generation; their office being, in all probability, to assist in the transit of the male fluid to its contact with the female ovum. The presence then of these spermatozoa, by which name we shall continue to call them, is to be regarded as sufficient evidence by itself of the existence of male organs of generation.

The generative process has been divided by some authors into various kinds, under the titles of nonsexual and sexual; and the former again into fissiparous, or generation by division; gemmiparous, or generation by buds; and gemmuliparous, or generation by separated buds or spurules. Such distinctions only lead to confusion, and divert the mind from that beautiful simplicity and uniformity of action which exists throughout nature; for, in the first place, it is doubtful, as stated above, whether such a thing as non-sexual reproduction ever takes place in the animal kingdom; and in the second place, the reproduction, even of the human being, includes in its processes the phenomena of both fissiparous, gemmiparous, and gemmuliparous generation, inasmuch as the vesicle which forms the human ovum is first produced as a bud in the interior of the organ (*ovary*), forming it, which, splitting on its surface to give it exit, simulates in every respect that which, taking place in the infusory animals and polypes, has given rise to the term gemmiparous and fissiparous generation.

In tracing the various circumstances which attend the reproduction of animals, from some of the lowest to the highest forms, we are struck with the fact that the generation of the simplest of animals bears much more analogy to that of the lowest vegetables than to that of the highest; and even in the animal kingdom the phenomenon of reproduction is present without the possibility, in all cases, of detecting the instruments by which it is effected. There is an animalcule called the *Volvox globator*, globular in its form like the *Protococcus nivalis*, and which like it may be observed from the transparency of its tissues to propagate its species by the developement of cells or vesicles in its interior. These vesicles soon assume all the characteristics of their enveloping parent, and as soon as they are in a condition to seek their own livelihood, their prison is burst asunder, and the offspring gain their liberty by the sacrifice of the parent. But there are animalcules in whom the process is even more simple. The *Paramecium*, another of the polygastrica, may be observed slowly to divide itself into two nearly equal portions.

### *Reproductive Organs.*

Where an especial portion of the body of an animal is devoted to the reproductive function, such part is called an *organ of reproduction* or *generation.*

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Organs of generation, in their simplest form, consist only of the glands which secrete from the nutrient fluid of the creature those products from which the embryo is evolved. The generative gland in the female is called the *ovarium*, and its secretion *ova*, or eggs; the corresponding gland in the mele is called the *testis*, and its secretion *semen* or spermatic fluid. The glands constitute, then, the essential organs of generation, and from their usuel situation may be called the *internal series*, as distinguished from the *median and external* series, to be described hereafter.

In a physiological point of view it will be found that, however widely we may extend our observations into the anatomical arrangement of these glends throughout the animal kingdom, end notwithstanding the amazing variety of form which they assume, they may all be considered, as in the case of the organs of respiration, merely as various arrangements of a particular surface, the blood-vessels of which are endowed with a peculiar function—the peculiarities of form having relation rather to the size of the animal, its locomotive powers, and its position in the scale of existence, than to the character of the germ which it is the office of these glands to produce.

The simplest forms of polypes are those without ciliated erms, such, for instance, as the *Hydra viridis* and *Hydra fusca*, specimens of which may easily be procured in our own ditches, and were at one time cited as illustrating gemmiperous generation, and as exhibiting the phenomenon of reproduction without any especial organs of generetion. This arose from the fact that young polypes might be observed shooting forth like the buds and branches of a plant from the surface of the polype, giving it the hydra-form appearance whence its generic title has been derived. But the observations of Ehrenberg have shown an especial portion of the body devoted to the reproductive function, or, in other words, that they have organs of generation. These consist of cells at the root of their arms and at the base of the stalk-like foot; the former performing the office of male organs, secreting semen and spermatozoa, and the latter female organs, secreting ova. So that it is more than probable that the appearance above referred to is merely the result of the adhesion of the ova to the body of the parent, for the purpose of further nutrition end protection after they are excluded from the ovarium, corresponding to what is met with in the highest classes of animals.

In some of the coral-like polypes, which are supported in the ocean by horny or calcareous deposits, we occasionally find, as in the *Campanularia dichotoma*, an especial case or womb, springing forth at the bifurcation of the joints for the protection of the ova during their developement. In the *Actiniæ* or the fleshy polypes, familiarly known as sea anemones, the ova are produced in a space which is left between the external covering of the body and stomach, in which situation a set of spiral tubes containing spermatozoa have also been detected, affording a simple but onequivocal instance of hermaphroditism, the ova which escape into the stomach receiving in their transit the influence of the fecundating fluid of the male organs.

In many animals there is no difference in the external appearance of the ovaries and testes, and it is only by the presence of the spermatozoa, or the alteration in the ovary during the breeding season from the ova, that the two sexes can be distinguished, as for instance in the *acalephæ* or sea-nettles, and among fishes, in the lampreys, eels, &c.



### *Of the Internal Series of Organs.*

*In the Female.*—With regard to the various forms of the ovary, which forms the essential and internal portion of the female generative system, the following classification by Burdach* is perhaps the most simple:

1. "A tubular ovary," consisting of canals closed at their extremities, either branched or simple, and continuous, with an excretory tube called the oviduct, as met with in many insects, some of the lower crustacea, worms, and certain mollusca.

2. "A cellular ovary," in which the portion secreting the ova is separated from the excretory duct; the texture in these glands is designated by Von Baer the *stroma*. It consists of cells, or separate spaces, in which the walls are burst by the ova when they arrive at maturity. This order includes—

I. The interstitial, hollow conducting ovary, very similar to the tubular ovary, only that the ova are at first separated from the excretory duct by a mucous membrane which they rupture when mature; such exist in the cephalopoda, the scolopendræ, in some crabs, in the arachnida, and in most fishes.

II. "A hollow interstitial receptacular organ," met with in all reptiles excepting the chelonia. These ovaries are not in immediate connection with the oviduct, and the ova escape at first into the cavity of the peritoneum.

III. "A full interstitial ovary," the receptacular cavity and the oviduct having disappeared. In some fish, such as the lamprey, *Petromyzon fluviatilis*, the sturgeon, *Acipenser sturio*, the eel, *Muræna anguillo*, the salmons, *Salmo salar et furio*, and the loach, *Cobitis fossilis*. Each ovary is a simple lamina, consisting of an internal membrane smooth and serous, of a middle membrane, thick, firm, and cellular, provided with longitudinal interlaced or parallel fibres.

3. "Vesicular ovary." This form is peculiar to some cartilaginous fishes, to chelonia, birds, and mammalia. It consists of a modified cellular tissue or parenchyma, covered by peritoneum, and containing several close vesicles, each of which is the laboretory for the formation of an ovum. This ovary looks like a bunch of grapes when the vesicles project from the parenchyma, as in the cartilaginous fishes, chelonie, birds, end some mammalia, as in the rodentie, insectivora, and some marsupiata, the Kuela and Wombat for instance, also in the Ornithorhynchus.

*In the Male.*—The secreting surface of the testes is generally, though not always, arranged in a tubular form, and the following summary from Müller† will give our readers some idea of their amazing variety.

1. In insects the testes consist of vessels and cæcal utriculi in great varieties.

2. In the gasteropodo it is made up of lobules which are dilated into racemose vesicles.

3. In the cuttle-fish and frog the testis consists of tube-like utriculi, sometimes ramose sometimes bifurcated, which shoot out from the centre and become more numerous as they radiate to the surface.

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* Burdach, *Traité de Physiologie*, translated into the French by Jourdan, vol. i. p. 162.

† *De glandularum penitiori structura*, translated by Sully.

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4. In osseous fishes most of the canals arise from a lateral excretory duct; they are divided into small branches and sometimes are joined in a reticulate manner, the ends of the canals being cæcal and budlike.

5. In the higher amphibia, the large seminal ducts are twisted into convolutions without any ramifications.

6. Which convolutions, in birds, mammalia, and man, increase more and more on account of the great length of the canals; but the canals are not ramose, nor are they attenuated as far as their cæcal extremities, but of an equal diameter throughout.

### *Of the Median Series of Organs.*

The principal office of these organs is to transmit the secretions of the glands already noticed to the third series, for the purpose of their complete evolution.

*Female Organs.*—In many females of the lower animals, and in most fishes and reptiles, and in all above them, are found ducts or tubes, which conveying off the ova as they are formed are called *oviducts*. In the lowest animals the oviduct is a direct communication from the ovary, similar to the excretory canal of other glands. But in the highest, the oviduct is quite detached, commencing a free trumpet-shaped opening. The rays, sharks, and chimæra are the only fish in which this form of oviduct is met with, but it is constant in all reptiles, birds, and mammalia, without exception. In the simplest oviducts their office is solely that of conducting outwards the ova, but very soon that tube is found to be employed in secreting substances for the protection of the excluded ova. Some of the secretions of the oviduct are merely to facilitate the passage of the ova, some to add a nutrient matter to be consumed by the ovum during the progress of developement, and others to protect, mechanically, the ovum after it is excluded. As familiar instances of the last operation, may be mentioned the horny pouches which protect the ova of the skates and sharks; the gelatinous matter by which the ova of frogs and toads are cemented together and floated on the water; and lastly, the egg-shells of birds, all of which are secreted by especial portions of the duct appropriated to that purpose.

In the mammalia, those accessory glands and the oviducts, which are so numerous in egg-producing animals, have almost disappeared. The oviducts are diminished in size at their ovarian extremities, but two in number, they unite more or less distant from their peripheral extremity; and dilated, form a cavity variable in size, called the *uterus*.

The uterus of mammalia differs, however, from the simple dilatations of the oviduct which are met with in many of the lower animals, in this important particular, (with the exception afforded by the marsupiate animals,) namely, that it is not a mere resting-place for the ovum, while the shell or other protecting matters are added; but that through the medium of its vascular walls the ovum is re-connected by means of blood-vessels to its mother: and in this way a constant supply of nutriment is afforded during the process of developement.

That portion of the united oviduct which is between the uterus and the peripheral extremity of that tube, or its external opening, is called the vagina.

*Male Organs.*—Under this head Burdach places first the organs by which the semen is emitted. "Fishes with vesicular testicles," says this distinguished writer, "are the only animals in whom organs for the emission of semen are wanting. Such is especially the case in the lamprey, in whom it appears that the semen penetrates the abdominal cavity across the envelope of the testis and passes from thence into the cloaca by a conical vesicle."



The excretory ducts of the testis, which are called the *vasa deferentia*, present in different animals various dilatations; these must, however, be distinguished from the accessory organs. The vesicular dilatation which is met with in the frog just before the termination of these tubes in the cloaca, and a similar arrangement in birds, afford illustrations of this arrangement.

### *Of the External Series of Organs.*

*Female Organs.*—In many animals, the oviducts open externally with simple extremities, in others they unite before their termination with some other organ as a portion of the alimentary canal, or the respiratory and urinary organs. In many of the polypes and echinodermata they terminate near the oral extremity of that canal, in some of the gasteropod mollusca on the side of the neck. But more frequently the termination is near the anal extremity, as in fishes,* in which there is either a single opening placed on the mesial line immediately behind the anus and before the urethra, generally in a cleft, but rarely on the summit of a projection, or there are two openings situated on the side of the anus. As instances of the connection of the oviducts with the respiratory organs, of which the common whelk is a specimen, it may be mentioned that in the genus *Buccinum* and *Murex* the oviducts terminate within the pulmonary cavity, and in the family of Cuttle-fish in the respiratory sac which contains the gills.

Their connection with the urinary organs may be seen in the European tortoise, in which they open into the neck of the urinary bladder.

In others they terminate in a cavity, common to the urinary and digestive organs, called the cloaca. This is the case in most insects, for example in all the coleoptera or beetles, in cartilaginous fishes, in amphibia, in birds, and monotrematous mammals, as the *Ornithorhynchus*, &c.

In those animals in which there is a true uterus and vagina, as referred to above, the seminal fluid of the male being injected into the body of the female by means of an erectile appendix to ducts of the testis called the penis, which is inserted during copulation into the vagina of the female, there is always a corresponding organ appended to the termination of the oviducts called the clitoris. The clitoris is in structure a miniature penis, but instead of being an organ of intromission, it is an organ for excitement of the venereal passion.

*Male Organs.*—These† may consist of either merely a simple opening of the different canals which during fecundation is applied to the opening of the oviduct of the female, or a cylindrical organ of intromission, as stated above. In those aquatic animals in which there is no real connection for the purposes of fecundation, but the sperm of the male is merely sprinkled upon the ova of the female while floating in the water, as in most fish and many amphibia, there is nothing approaching to an organ of intromission. In many other animals, as in most birds, the membrane of the cloaca, upon which

* Burdach, *loc. cit.* p. 217.

† *Ibid.* vol. i. p. 223.

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the *vasa deferentia* terminate, is capable of such eversion that the orifice of the seminal tubes is brought into contact with the lining membrane of the female oviduct, but without an especial organ of intromission. The exceptions to this mode of connection among birds are observed in the ostrich, which in many points of its organization approaches the mammalia, and in the lamellirostrous birds, as ducks, &c. which perform this function in the water. In these birds there is a very perfect intromissive organ, but distinguished from a true penis in having a mere groove instead of an urethral canal receiving the vasa deferentia.

The penis of the male is not alike in all animals: in some it is only an imperforate organ for exciting the female previous to connection. Occasionally, however, other additional excitements are furnished, as, for instance, the love-darts which the snail throws at its mate before a closer approach.

An imperforate penis of this kind is met with in many hermaphrodites,* as in the earthworm among the annelida, in the *Doridum coriaceum* among the gasteropoda, in the *Hyalæa* among the pteropoda.

In the earthworm there are two solid conical bodies, one situated on the twenty-fourth segment of the body, according to Leo,† or at the clitellum, according to Moreau,‡ whilst the orifice of the vasa deferentia and oviducts is found at the sixteenth ring.

The dragon-flies, according to Rathke,§ have a penis at the second ring, and the opening of the vasa deferentia at the ninth; and in the crabs the vasa deferentia open at the base of the last pair of claws, while at the inferior face of the first caudal ring there are two small horny and movable rods very like a true penis.

A single grooved penis is characteristic of all the vertebrata below the mammalia. In serpents it is double, but it does not appear externally when in a state of repose, nor indeed in any animal in whom it would have interfered by its projection with the progressive movements of the creature; but in a state of erection it is protruded from the cloaca.

In crocodiles and the turtles the penis is single, short, and grooved along its under surface.

A true penis, with a tubular canal called the *urethra* running down its centre, is the peculiar attribute of the mammalia, and in the higher classes its canal commences in the urinary bladder, the vasa deferentia communicating with it nearer the external orifice. In the implacental mammalia, as the monotremata and marsupiata, there is no appearance of penis externally, for in a state of rest it is folded back and concealed in the cloaca, and hence the origin of the term *monotrematous*, or with a single outlet, as applied by Geoffroy St. Hilaire. The penis in this class is also independent of the ducts of the urinary glands, which terminate, as in the turtle, lower down in the cloaca, and transmits only the semen.

The structure by means of which the penis is erected and fitted to become an efficient intromittent organ, is the same in all animals, though its extent is various. It consists of a plexus of blood-vessels capable of distension and contained in a fibrous sheath, so that when these vessels are full the sheath becomes distended and rigid.

In all animals in which the semen has to be carried some distance from the organ which secretes it to the ova of the female, accessory glands to the testes are found: these in man are known under the title of the *vesiculæ seminales*, the *prostate gland*, and *Cowper's gland*; their office is to secrete a fluid to be mixed with the semen and carry it onwards.

The prostatic glands in mammalia almost always consist of intestinules, or large ramose follicles. The number of glands occupying the place of a prostate gland varies very much: sometimes there is but one, with differences in its conformation; sometimes it is joined with vesiculæ seminales, and sometimes without them. The prostate glands are of great size in most of the rodentia and insectivora, as in the rat, hedgehog, and mole.

"Cowper's glands,* though so small in man, are very remarkable in many mammalia, and offer in different species a different conformation.

"1. The most simple is the compound follicle, such as frequent observation has shown to exist in man.

"2. In some other of the mammalia, as in the squirrel, conical sacs occupy the same situation, the fundus of which presents twisted cellules with prominent laminæ, similar to the preputial glands of mice, and by the testimony of Cuvier, in the common marmot, the bobai, and wild hog.

"3. In the beaver, Cowper's glands exhibit a compact spongy texture; and the same structure is met with in these glands in the European mole.

"4. In the zibet, in the cat and hyæna, they are very large and lobulated.

"5. In the ichneumon, as Cuvier has shown, the glands are formed by vesicles joined together and terminating in a single duct.

"6. These glands, in the European hedgehog, are situated partly in the pelvis under the pubic bones and the ascending ramus of the ischium, and partly out of the pelvis towards the internal surface of the femur, and are joined at some distance to the other glandulæ succenturiatæ, and further on to the excretory ducts of the urethra. They consist of a large number of pyramidal lobules of a white colour, which are collected in fasciculi by the apices or trunks of the canals. The common excretory duct receives many fasciculi. Each lobule consists of smaller lobules, both flat and pyramidal, almost of equal length, on which, however, the tubuliform secreting canals ramify, scarcely discernible, in a fasciculated manner, and are distributed, increased in size, as far as the hind extremities. All the lobules are formed of single tubes united by cellular tissue, and air being blown through the tube into the canals, they offer a beautiful appearance. According to micrometrical calculations, the extremities of the canals are 0·01022 of a Paris inch in diameter.

"Cowper's glands are similarly formed, from what we can collect by the brief observations of Cuvier, in the *Didelphis cayopollin*, *Phalangista*, *Phascolomys*, *Halmaturus giganteus*, or large kangaroo, and *Hypsiprymnus* or kangaroo rat. Cuvier states that this gland is formed in all these animals by plexuses of vessels.

"From these minute details we learn then that ana-

* See Burdach, p. 231.

† *Diss. de Structura Lumbrici Terrestris*, 1820, quoted by Burdach.

‡ *De Lumbr. Ter. Hist. Nat.* p. 77.

§ *Miscellan. Anat. Physiologica.* Kœnisb. 1832; in 4to.

* Muller, *De Glandularum Structura, &c.*, translated by Solly, p. 54.

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Zoology. logues of the vesiculæ seminales and prostate gland are almost universal among the mammalia, though their form and arrangement are greatly diversified, and that Cowper's glands, which are so small in the human subject, are complicated in structure and of large size in many other of the mammalia, for instance, in the common mole, the cat, the ichneumon, and hedgehog."

*On the Progressive Developement of the Ovum.*

We are indebted to De Graaf for having first clearly established the true function of the ovarium as the secreting gland of the ova, by sound and carefully conducted observations. It is true that the vesicles which now bear his name had been previously observed by Vesalius, Fallopius, and Bartholin, and by his contemporaries, Van Horne and Steno, by the last of whom they had been described as ova, but they had not proved it satisfactorily. These observations of De Graaf were strongly opposed at the time; and the notion of Haller, that the ova were formed in the Fallopian tube out of a substance discharged from the ovary, was more generally admitted. Nearly a hundred years after this discovery of De Graaf, Cruikshank came to the same conclusion, but without succeeding in discovering the ovum in the ovarium. Prevost and Dumas, in 1824, describe the difference in size between the ova which they found in the cornua of the uterus and the "vesicles or ova of the ovary," which difference they considered to depend on the presence of a fluid intended to facilitate their descent to the uterus. Von Baer's observations in 1827 * were more minute, and they form one of the most important steps in the history of developemental anatomy. He observed certain white spots on the vesicles of De Graaf in the dog without any assistance from the microscope, the position of which could be altered. And by the aid of the instrument he discovered true ova, exactly similar to those in the Fallopian tube. These ova varied in size from the $\frac{1}{12}$d, $\frac{1}{21}$st, and $\frac{1}{32}$d of an English line. They appeared surrounded by a ring of granules, to which he applied the term *discus proligerus*, and to the projection which these granules formed, the title of *cumulus*.

It is somewhat curious that the ova of mammalia, which for a long time were supposed, from their minuteness and opacity, the most difficult for investigation, should, in the hands of our intelligent countryman Dr. Barry,† have been the means of throwing more light on this interesting subject than those of any other class of animals. It has been stated that when an especial portion of an organism is appropriated to the production of ova, such portion is called an ovary or *ovarium*. The products of all ovaries are simple vesicles, first discovered in the ovarian ovum of the bird, by Purkinje,‡ and called the *germinal* or *Purkinjian vesicle*.

They were afterwards discovered, in 1827, by Von Baer, in mollusca, annelida, crustacea, and insects, as also in some oviparous vertebrata. In 1834 by Coste, in the mammalia, (rabbit.) By Purkinje, Bernhardt, Valentin, and Wagner, in the same year, in mammalia generally; and in this country by T. Wharton Jones, in 1835, in the rabbit.* Since, they have been observed by most physiologists. Zoology.

These vesicles are secreted in great numbers even in the mammalia, in whom the number of offspring are comparatively very limited. Dr. Barry has reckoned about fifteen hundred millions to be included in a single cubic inch.

The same organ which forms these ovisacs also partially provides for their future protection and support, investing them with oil-like globules, which in the aggregate constitute the yolk or *vitellarium* of Owen, and a firm protecting membrane, *zona pellucida* of Barry—the entire structure constituting an ovisac or ovarian ovum as distinguished from the ovum which has quitted the ovarium.

Previous to the researches of Dr. Martin Barry, it was supposed that the germinal vesicle burst at the time of impregnation, and, scattering its contents, gave rise to the germinal membrane from which the organs of the embryo were evolved. But this is not the case; the germinal vesicle only ceases to be pellucid in consequence of its becoming filled with cells, which also become filled with the foundation of other cells.

The germinal spot, says Dr. Barry,† is known to present in some instances a dark central point, which makes its appearance at a certain period, and, enlarging, resembles a dark globule or ring, which contains a cavity filled with fluid, which is exceeding pellucid. The germinal spot itself assumes the appearance of incipient cells.

The cells enlarge so as gradually to occupy the whole of the interior of the germinal vesicle, except the part from which they arose. The germinal vesicle passes from a globular into a flattened form, and also becomes enlarged. The position does not change, but it becomes more determinately applied to the investing membrane than in the immature ovum. The pellucid part of the altered germinal vesicle at which the foundations of new cells arise is directed towards the surface of the ovum, so as to face an attenuated spot or orifice in the thick transparent *zona pellucida* which invests it. By this spot or orifice it is supposed that the seminal fluid comes into contact and actually penetrates into the germinal vesicle, inasmuch as spermatozoa have been found in actual contact with the ovisac, both by Professor Bischoff of Heidelburg and Dr. Barry.

After impregnation has taken place the germinal vesicle returns from the circumference of the ovum to its centre, and regains its globular form, the vesicle itself becoming closely surrounded by a layer of cells; each of which presents a remarkably opaque nucleus: subsequently this nucleus seems to resolve itself into cells, and layer after layer of cells make their appearance in the interior, while cells occupying a more external situation undergo liquefaction. The central point of the germinal vesicle, which has been mentioned as lying immediately under the transparent membrane to receive the influence of the fecundating fluid, presenting the appearance of a minute cavity with dark walls, and containing a pellucid fluid, passes from the surface to the centre, at which spot two cells come into view. These two cells constitute the foundation of the new being, that is, the germ.

The nucleus in each of the twin cells, which together

* *De Ovi Mammalium et Hominis Genesi*, Lips. 1827.

† See his papers in *Philosophical Transactions* for 1838, 1839, and 1840.

‡ See his *Symbolæ ad Ovi Avium Historiam ante Incubationem*, 1825.

* See an excellent paper on this subject in the *British and Foreign Medical Review*, vol. ix.

† Martin Barry, *Phil. Trans.* p. 531.

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with the germ undergoes essentially the same changes as those presented by the germinal spot, seems to pass sooner than the centre of the altered spot to the interior of its cell. The nucleus having increased in size, dark objects, the foundations of new cells, come into view in its interior, and these enlarging present a set having a still more central situation. The pellucid centre of the nucleus eventually increases considerably in size. The two cells which constitute the germ distend until they nearly fill the germinal vesicle; this takes place at the expense of the surrounding cells with which, it will be remembered, the germinal vesicle had filled.

These surrounding cells having successively enlarged disappear by liquefaction, the outer layer of them being apparently the first to undergo this change. The inner layers are at first pushed forth by the two distending cells, but eventually liquefy, and thus the contents of the germinal vesicle, again reduced to fluid, enter into the formation of the two central cells, these being destined to succeed it. The membrane of the germinal vesicle, distended to a large size and still present in the ovum, disappears by liquefaction. This vesicle is therefore not a "cytoblast," as supposed by Schwann, but a parent cell; and of the numerous progeny of cells which arise within it, only two remain as its successors.

While the changes just described are in progress within the germinal vesicle, membranes continue to form, and disappear successively around the layers of discs or cells by which this vesicle is surrounded.

The germinal vesicle itself, or the original parent cell, next disappears, leaving in its place the twin cells above referred to. Each of these twin-cells gives origin to others, making four. Each of these, in its turn a parent cell, gives origin to two, by which the number is increased to eight; this mode of augmentation continuing until the germ consists of a mulberry-like object, the cells of which are so numerous as not to admit of being counted. Together with this doubling of the number of cells there occurs a diminution in their size.

The above observations were made on the rabbit, and whether such changes as those just described take place in other animals or not has not yet been decided, but reasoning from analogy it may be considered most probable that they do.

In the very lowest animals, in almost all of which the germinal vesicle has been detected, it has been found obscured by the acts of fecundation. For instance, in the Acalepha, if the ova of the ovarium are examined, the vesicle is found distinct, but in those which are contained in little marsupia or pouches attached to their fringed tentacula, to which parts they are removed during their gradual developement, the germinal vesicle can no longer be seen. And as the sexes are distinct, some of them containing spermatozoa in their generative sacs instead of ova, it is reasonable to suppose that impregnation takes place in their passage from the ovary to the marsupia.

In the following enumeration of the parts composing the ovum of a mammal, the order in which they are formed has been followed; it being most probable that the same arrangement, in accordance with the uniformity of the laws of nature, exists throughout all classes of animals.

1. The Germinal vesicle, soon followed by

2. An envelope consisting of oil-like globules and peculiar granules, that is, nucleated cells.

3. The ovisac, which is formed around and from the envelope just mentioned.

4. The yolk produced within the ovisac around the germinal vesicle; and

5. Its proper membrane, which makes its appearance while the yolk is still in an incipient state.

6. The proper covering or tonic of the ovisac, a transparent membrane, *zona pellucida*, and about the same time the peculiar granules of the ovisac arrange themselves to form the tunica granulosa, the retinacula, and the membrana granulosa. Of these the *retinacula* embrace as a membrane the ovum in its *tunica granulosa*, giving off cords or bands which extend to the *membrana granulosa*, and thus suspend the ovum in the fluid of the Graafian vesicle. It is also possible that their office is to convey the ovum to that part of the periphery of the vesicle at which impregnation takes place; to retain it there, and finally to promote its expulsion from the ovary.

7. And lastly a protecting membrane formed from, and continuous with the tissue of the ovary, the *Graafian vesicle*, analogous to the calyx in the ovary of the bird.

From the preceding observations it will be seen that the ovum is not a minute representation of the future being from which such being is evolved, any more than the food which the mother takes into her stomach is a miniature representation of the germ which that food goes to nourish. The gradual progress of nutriment from the stomach can be traced until it is converted into blood; and as blood, we can trace it to the different organs of the body, where we see effects produced by its presence, and which are never observed without it; and the same may be said regarding the evolution of the ovum, that there is a course of certain changes which may be watched, but of the immediate agent in producing these changes we know nothing.

The class of animals called *mammalia*, or mammals, were long supposed to be distinguished from all others by the circumstance that the ovum, after being expelled from the ovary, was re-attached to the parent by blood-vessels, for the purpose of receiving the continuance of a supply of nourishment during its developement. The patient and interesting observations of Professor Owen regarding the generative functions in marsupiate animals have shown that there are exceptions to this rule; and as the blood-vessels referred to above, which connect the parent and the embryo, form a more or less consolidated part called anatomically, from its plate-like appearance, the *placenta*, they have been divided into *placental* and *implacental mammalia*.

With the exception then of the placentally developed mammalia, which include all except the marsupiata and monotrematous mammalia, the ova of all animals on their exclusion from the ovary are provided with a supply of nourishment sufficient for the developement of the embryo, until it is so completely formed as to be able to use its own organs of digestion, and to assimilate fresh materials for itself. This store of nutriment is twofold, one portion, called the yolk, with its investing membrane, or *vitellarium*, is provided by the ovary; the other, the white of the egg, or *albumen*, by the oviduct.

The great size of the yolk-bag, or vitellarium, in the bird is familiar to every one, while its small size in man and the placental mammalia induced anatomists to designate it by a different title, namely, the *umbilical vesicle*.



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But a supply of nourishment is not the only requisite for the growth and developement of a living being, some provision for the purification by air of the nutritious juices or blood of the embryo, or, in other words, organs of respiration, were equally necessary. Those ova which are deposited and developed in the water, like the simplest forms of polypes, do not require the appropriation of any especial part of the body to the performance of the respiratory function, as the external surface is equally adapted to it. And in the simplest animals we find the surface of the vitellarium, or yolk-bag, performing the part of a respiratory organ, and affording an extensive surface for the spreading out of the purifying blood-vessels. But in the embryo of the terrestrial vertebrata, viz. the higher reptiles, birds, and mammals, there is always a transitory respiratory organ, called, from its sausage-like form, the *allantois*.

The *allantois* is a membranous bladder springing out from the lower end of the alimentary canal, and over which thousands of blood-vessels ramify, uniting again and again as in the lungs of the perfect creature, and affording an extensive surface for the exposure of the blood to the decarbonizing action of the atmosphere. The allantois is of large size in the bird and in the kangaroo. In the human being, and the placental mammalia in general, it is little more than the foundation upon which the placenta is constructed. It forms a sort of bridge for the passage of the blood-vessels of the embryo to the surface of the uterine blood-vessels of the mother.

The gradual evolution from the ovum of the various organs which compose living creatures cannot be traced with equal facility in all classes of animals from their small size in some, the mammalia for instance, and the difficulty of procuring them in sufficient numbers in others. But as these difficulties do not apply to the ovum of the common fowl, more is known regarding its developement than of other animals; while, at the same time, all that has been observed relative to the human being and mammalia in general goes to show that the progress is identical in both.

### *Developement of the Ovum of the Bird.*

The external covering of the egg in the bird is solidified by the deposit, from the blood-vessels of the oviduct, of calcareous matter as it descends from the ovary; but the shell which is thus formed remains permeable to that air which is so essential to the existence of the embryo.

The shell is lined by two membranes, the one external, rough, and adherent, the other smooth and polished to allow of the rotation of the egg within. In contact with this smooth membrane is the albumen, or white of the egg, (a store of nutriment,) in which the yolk floats suspended by two prolongations of a membrane which envelopes it. These prolongations are spirally twisted cords, called the *chalazæ*, and are supposed to be agents in bringing the embryo always to the upper surface, in order that it may receive the full influence of the heat of the mother.

Beneath the chalaziferous membrane is situated the proper yolk or *vitellary membrane*.

If the egg-shell of the common fowl is broken, and the surface of yolk examined before incubation has commenced, a whitish round spot may be seen, about one-sixth of an inch in diameter. This is called the *cicatricula*, or *germ spot*, the *discus proligerus* of Von Baer. The researches of Dr. Barry, already referred to, tend to show that this spot consists of the aggregation of nucleated cells developed from the parent cell or germinal vesicle, which is thus concealed by this layer. The central portion of the cicatricula is more transparent than the rest, and is called the *transparent area*.



The first effect of incubation is to increase the surface of the proligerous membrane, and to separate it more decidedly from the yolk. The proligerous membrane, acquiring more consistence, becomes separated into two layers, the superficial one is thinner and firmer, the inferior thicker, more granulated, but less coherent. With the aid of the microscope we are able to distinguish this separation before the twelfth hour, by tearing gently the proligerous membrane with needles. This may be seen more distinctly a little before the appearance of the embryo than afterwards. The superior layer is the serous layer of Pander, the inferior layer is the mucous.

Nearly at the same time that this separation is effected in the thickness of the proligerous membrane, there is another operating from the centre to the circumference; the centre of the membrane becomes more clear, its figure is more decided, because the serous layer predominates in the first point, and the mucous in the second.

The clear space of the centre, denominated the *area pellucida*, is at first round* and next elongated, and soon becomes larger at one extremity, passing from an oval form to that of a pear, which it maintains generally towards the twelfth hour, and until the formation of the cephalic cowl of the embryo.

Towards this period, the proligerous membrane has a diameter of three or four lines; and, with the exception of its border, is strongly curved, from whence it results that at this point the vitelline membrane makes a projection like that of the cornea of the eye. The white diminishes then above it, but the diminution is too considerable to depend only on the arching of the proligerous membrane and the vitelline which covers it.

It very soon appears that the entire sphere of the yolk rises more and more in the white, so that the proligerous membrane, which always occupies the superior part, approaches the shell.

This change is more evident on the following days than the first; whilst at this time the proligerous membrane is completely separated from the parts situated beneath it: for the vitellary membrane may be raised without the *cumulus* of the proligerous membrane, at the superior surface of which we can perceive a projection surrounded by a circular white border.

A circular furrow containing a clear fluid separates this border from another white circle which the yolk forms, and that a furrow separates in its turn from the mass of yolk situated immediately external to it.†

These circles, and the furrows full of liquid which separate them, are perceived across the proligerous membrane, and are denominated the halos.

The *halos* commence a little after the eighth hour; at first circular, they become oblong afterwards, and increase with the proligerous membrane. Their number is from *two* to *three* at first; but at the second day the elevations which separate the circular projections break, and the projections are confounded together in

* Burdach, vol. iii. p. 204. † *Ibid.* p. 202.

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a wavy manner, rendering it almost impossible to determine the number of the halos.

Between the sixteenth and twentieth hour,* in the depressed part of the proligerous membrane, is observed a circular line of a colour more dull than the rest, which projects below as a flattened seam, and divides the deepened portion of the proligerous membrane surrounding the transparent area into two circles, the one *external*, the other *internal*; in the latter of which the vessels are formed, and appear on the second day, giving rise to the title of *Area Vasculosa*.

Before this separation takes place on the surface, another and corresponding one, but less visible, is going on in the substance of the proligerous membrane.

Between the serous and mucous layers, a layer of globules is formed, which Pander called the *vascular layer*, because the vessels are subsequently developed from these globules. This layer is absent in the external ring, but exists in the transparent area and in the vascular area, and predominates as a true vascular layer.

Up to the middle of the first day there is no appearance of any portion of the future embryo. It is only towards the fourteenth or fifteenth hour that the first rudiment can be perceived. This consists in a line or streak called the *primitive band*, which is the precursor of the spinal column. One extremity of this streak may soon be observed slightly swollen, indicating the future position of the head of the chick, and this position is always the same; for instance, if the large end of the egg is placed nearest to the observer, the streak stretches across the area on the left side, on which is also situated the swollen extremity, while that which corresponds to the body of the fœtus extends towards the right.

About the sixteenth or eighteenth hours the sides of this streak soon rise into folds, called by Pander the *plicæ primitivæ*. They are of a deeper colour than the surrounding cells and the space which they enclose. Baer calls them the *laminæ dorsales*, and they are the rudiment of the spinal column.

At the same time that the laminæ are appearing, another part is in the progress of formation, the *chorda dorsalis*, the anterior extremity of which soon presents a rounded point; so that, at the end of the first day, the dorsal cord resembles a very fine pin with a delicate head. This cord evidently, says Burdach, corresponds to the cartilaginous column which is found during the whole life-time in the spine of some cartilaginous fish, though it has been mistaken for the spinal marrow, which is not formed until the union of the *laminæ dorsales*, which, corresponding to the arches of the future vertebræ, form its protective canal. The appearance of a separation into vertebræ, five or six in number, may be seen towards the end of the first day.

The *mucous layer* is very thin, and simply in apposition with the inferior surface of the vertebral column. The *serous layer* is continued without interruption from the laminæ dorsales, and the whole embryo is curved downwards into the vitellus like a flat-bottomed boat.

On the second day the laminæ dorsales begin to unite, commencing behind the future head and extending backwards; the number of rudimental vertebræ increase to ten or twelve, and, becoming dilated into a distinct cavity anteriorly, form the rudiment of the cranium, behind which, about the thirtieth hour, a second cavity for the protection of the tubercula quadrigemina, or optic ganglia appears, shortly followed by a third, for the *medulla oblongata*, all which portions of the nervous system, though at first fluid, become slightly solidified about the end of the second day.

The *laminæ** *centrales*, or visceral laminæ, *laminæ abdominales* of Wolff, *plicæ ventrales* of Pander, reunite below to produce a cavity as the *laminæ dorsales* do above, only their progress is much slower, and not completed until the end of incubation. They exist at the anterior extremity from the beginning of the second day. In consequence of the curving downwards of the embryo both anteriorly and posteriorly, a cavity is gradually formed, lined by the mucous layer, which is the commencement of the alimentary canal. During the first half of the second day, the rudiment of the eye, as a dark spot, appears to spring out from the anterior cerebral cell, and the ear, as a hollow cylinder lined by nervous matter, from the medulla oblongata.

While these changes are proceeding in the mucous and serous layers, equally important ones are going on in the vascular, both as regards the evolution of the blood itself and the vessels which are to contain it. According to Pander, there appears very early, under the serous layer, small islands of a deep colour, and composed of small globules. Towards the twentieth hour, this appearance of islands disappears, and the entire surface is uniformly filled with globules, between which small fissures are manifested; at the end of thirty hours they are reunited into islands which become elongated and narrowed, and uniting together by their extremities form a reddish network with transparent interstices, containing delicate currents of blood.

The first rudiment of the heart appears towards the twenty-seventh hour, on the lower side of that anterior fold of the mucous layer which afterwards forms the œsophagus, at the place where the larger germinal membranes are reflected from the edge of the short sac which forms the embryo, as an elongated canal with two prolongations or crura. Burdach says, "it seems to me that the motion first commences in the heart, and that shortly after the current appears in the furrows of the transparent area, and that last of all, the blood proceeds from the vascular area."† This is certain, that for some hours there is moving in the heart a perfectly limpid fluid before there is any motion in the area.

The first motions of the heart are undulatory, but after two or three hours, it may be seen driving forward the fluid which it receives by its lateral veins; each expulsion is succeeded by an interval of repose, during which the heart is dilated and slowly absorbs the blood in the veins, after which it contracts, the action lasting some little time.

The two canals which come off from the anterior extremity of the heart are very distinctly developed towards the end of the second day. Embracing the guttural cavity, they extend up to its arch, that is to say, up to the inflected surface of the vertebral column, and at this spot, at the anterior limit of the internal excavation of the body, they are curved from below upwards running along the anterior face of the spine and reuniting after having been separated during some time,

* Burdach, p. 204.

* Burdach, *loc. cit.* iii. p. 215. † *Ibid.* p. 223, *loc. cit.*



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which is very manifest before the end of the second day.

The first current appreciable in the heart proceeds towards the anterior extremity of the brain, to which it appears primarily attracted. The remainder of the vascular system at this period presents the following form: a grand reservoir which next to the heart is the largest canal destined to receive the blood, formed of two semicircles, which separate the vascular area from the vitelline area; this is called the *sinus terminalis*, and when its walls become perfectly distinct, then it is called the *vena terminalis*. The blood flows into this circle in the centre at the two halves, with a strong current from behind forwards and another weaker from before backwards. From this circle springs out a multitude of small veins, which, reuniting, form either one or two trunks which terminate in the heart, from whence the blood is propelled by a vessel corresponding to the bulbus arteriosus of the fish, inasmuch as true branchial arteries are given off from it in three pairs, which reunite to form the descending aorta.

About the middle of the second day, may be perceived behind the curved extremity of the *corda dorsalis* on its inferior surface, an arched line, of a deep colour, something like the reverse surface of a cicatrix; this opens on the third day and forms the mouth.

From the posterior extremity of the alimentary canal arises, a little after its formation and about the middle of the third day, a small vesicular hernia, the *allantois*, which on leaving the intestine resembles a blunt cone; but it soon contracts and its summit becomes hemispherical. Towards the end of the third day, it slowly increases to about the size of the head of a pin, and, seen from below it, scarcely raises the caudal cowl. It consists of two layers: the internal mucous, the external serous. The allantois is a temporary respiratory organ, provided for the aëration of the blood of the chick during its incarceration in the egg-shell, and if any doubt had existed regarding its real function, the interesting observations of Mr. Dalrymple, given at the Microscopic Society, on the arrangement of its capillary vessels, substantiated by excellently injected preparations, have established it clearly. This organ rapidly increases until it almost envelopes the embryo, lying close in contact with the under surface of the shell, where it receives the benefit of the atmosphere which easily permeates its porous case.

### *Developement of Mammalia.*

The observations of Baer have shown that the first formation of the embryo of mammalia is the same, as regards all essential circumstances, as those of the bird, and that where observation has left a void in the history of the embryo, we can call to our aid the analogy of that of the chick, not losing sight of the difference which ought to result from the fact, that the ovum of mammalia does not contain the same provision for nourishing the embryo as is necessary for the bird.

As the ovum of the mammalia descends through the Fallopian tube, it receives a covering called the *chorion*, which is intended to provide for a vascular communication between the embryo and the parent, during the sojourn of the former in the uterus of the latter.

The large yolk bag of the bird is represented in the placental mammal by a small vesicle called the *umbilical vesicle*. In the implacental mammal, as the kangaroo, this vesicle is of great size, as the fœtus is never reunited to the mother.

The *allantois* varies in size in different classes, but in none is it so large as in the bird, and smallest of all in the human being, acting merely as a sort of bridge or scaffolding on which those vessels pass to the chorion, from which is afterwards developed the placenta.

The form of the *placenta* varies in different animals, but in all it is a sort of spongy vascular cake or plate-like body, consisting of two sets of vessels, the one commencing and terminating in the fœtus and the other commencing and terminating in the walls of the uterus of the mother. The *surface* of the two sets of vessels are in contact, and through their *walls* the blood passes from one to the other, but there is no communication by anastomosis or open mouths.

In the implacental mammalia, the marsupiata, and monotremata there is no placenta, as the ovum, though it rests for a short time in the uterus, never attains any vascular connection to it, and the fœtus when expelled is more like a small earthworm than the active mammal which produced it.

### *Developement of the Human Ovum.*

As, among the mammalia, man is the being, the history of whose developement is most interesting to us, we shall select him as an illustration of the general course of its progress in this class, and the arrangement of Burdach in dividing the history into different periods will be pursued.

*First period.* The human ovum has been found in the Fallopian tube or oviduct about fifteen days after fecundation, presenting the appearance of small vesicles. Previously to the entrance of the ovum into the uterus, certain changes occur in that cavity to prepare it for the protection of its future inmate. An exudation of albumen takes place which is soon converted into a membrane, at first thin and delicate, but becoming thick, lines the whole uterus and acquires a strong vascular connection to it. This membrane is called the *decidua*, and the ovum meeting with it on its entrance into the uterus from the Fallopian tube presses it before, thus dividing it into two portions, the one remaining adherent to the uterus, the *decidua vera*, the other attached to the ovum, the *deciduo reflexa*.

The *second period* extends from the third week to about the fifth week, in which the embryo acquires proper parietes, separating it from the ovum, the single organs begin to appear, viz. the intestine, umbilical vesicle, allantois, liver, and heart, with the vascular trunks and ramifications, which run to the branchiæ and umbilical vesicle.

The *chorion*, and consequently the ovum, acquires the length of about ten to fifteen lines.

It is delicate, whitish, and transparent, and arising from its external surface are whitish, thin filaments, or cylindrical flocculi, which are some lines in length, and swollen at their free extremity: during the fourth week radicles shoot out from the sides; so that with its filaments it looks like a tree. These flocculi traverse the meshes of the decidua reflexa, and adhere to this membrane or the external caduca; so that at this period the ovum becomes fixed. In rabbits the ovum is attached to the uterus about the eighth day after impregnation:

* Burdach, p. 225. † *Ibid.* p. 253.

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in dogs about the sixteenth.* The cavity of the *chorion* contains an albuminous liquid, reddish and transparent, crossed in all directions by a delicate and colourless tissue.

The *amnios* now appears as a transparent vesicle, filled with a clear liquid like water, is much smaller than the chorion, and covers the dorsal surface of the embryo, extending laterally so as to form two fossæ, but not covering the ventral surface. By degrees the amnios advances more and more towards the ventral surface as it becomes turned upon itself by the increasing depression formed by the embryo, until it produces at the spot where continuous with the ovum a canal, the *umbilical sheath*, which at first is very short and very large, but finally becoming a little narrower, and acquiring a length of some lines, is at the same time applied immediately to the inferior extremity of the trunk.

The embryo has increased from a line to nearly three lines, weighing from one to three grains.† It is composed of a homogeneous mass, greyish, semitransparent, gelatinous, and appearing greenish under the microscope; at first extended lengthways, but very soon curved upon itself on the ventral side. The head is a simple spherical mass, without openings. At first narrow and low, scarcely distinct from the trunk, it increases with so much rapidity, that, after the fourth week, it has acquired the volume of the trunk, from which it is separated before by a slight transverse furrow, the rudiment of the neck; behind by angular projection of the tubercle of the neck, which is occasioned by the sudden inflexion of the medulla oblongata passing from the cord to the brain. During the fourth week the eyes may be seen as two black points on the disc of the head.

The trunk is without limbs, terminating inferiorly in a caudiform point. The parietes of the trunk, which consist partly of a granular mass and partly of a transparent membrane, grow from behind forwards, and unite early in the mesial line anteriorly to produce the thorax, leaving the abdomen free, continuous with the umbilical sheath.

*Behind* may be seen the vertebræ cartilaginosus, with the rudiment of ribs as white lines, two-thirds of a line in length. *Before*, on the ventral surface, there are two vesicles, continuous by canals with the mucous membrane of the abdominal cavity, extending towards the cephalic and caudal extremities; they are situated horizontally upon the ventral face of the embryo, and afterwards are found inclosed in the umbilical sheath.

From the embryo there is, in fact, given off a very small canal, about three lines in length,‡ extending from beneath the cephalic extremity, and terminating in the umbilical vesicle, which is spherical, a little larger than the embryo, of yellowish-white, translucid, granular, and tolerably firm, filled with a limpid or whitish fluid: when the umbilical sheath is formed it unites with it, becoming elongated by degrees, is removed from its original position, and having its canal elongated.

At the spot where the intestine is reflected upon itself the canal is continued into it; but during the fifth week it is obliterated at this spot and found reduced to a simple filament.

The intestine is white, opaque, uniformly cylindrical, short, extended in a straight line; coming off from the stomach, it is directed obliquely forwards to the umbilical sheath, reflected upon itself at the insertion of the canal of the umbilical vesicle, returns into the abdomen and terminates at the anus. These two portions of the intestine—the first the stomachal, the second anal—are united by a mesentery. Upon the anal portion, at some distance from the point of inflexion, the cæcum is indicated by a small prolongation.

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The second vesicle is the *allantois*, which in man disappears soon after its manifestation, from the fourth to the fifth week; so that it is rarely met with. But in other mammalia it persists during embryonic life.

The cylindrical, or allantoidal canal comes off from the extremity of the digestive canal, detaching itself at a right angle from its ventral surface, and is continued by a geniculated and dilated inflexion, with the vesicular and pyriform portion which is extended, parallel to the longitudinal axis of the embryo, up to its caudal extremity.* The allantois is white like milk, and Pockels states that he has perceived in its interior some red globules, which at first are scattered, but afterwards arranged in lines. Nothing is yet to be seen of the urinary system.

The heart is situated horizontally, the apex in front.

The omphalo-mesenteric vessels, that is, a branch of the aorta and a root of the vena cava, are spread upon the umbilical vesicle, and all filled with red blood.

The omphalo-iliac vessels are formed later.

The liver receives a great part of the omphalo-mesenteric veins. It is of reddish grey, very large, weighing about half as much as the whole body, divided into several lobes.

"The branchial apertures, which are situated in the transverse parallel folds upon the sides of the neck, have at their edges some branches of the aorta and vena cava, and are particularly well marked in other animals; but disappear at the end of this period or the commencement of the next."

*Third period.*—This period extends from the fifth to the end of the eighth week.† The lateral developement and projection of the embryo externally become more strongly marked, between which and the ovum a more decided line of demarcation is established. These changes are announced by the more marked lateral developement of the brain and spinal cord, by increase of the head and vertebral column, by the formation of the animal periphery, the cartilages, bones, muscles, and nerves; by the progressive formation of the sensorial organs, by the projection of the extremities, by the appearance of the openings of the intestinal canal and sensorial organs, by the production of pairs of excretory organs, the lungs, the kidneys, and genital organs; by the formation of the cutaneous projections, as the eyelids, lips, ears, and nose, penis and clitoris.

The ovum is oblong, almost elliptical; the perpendicular or longitudinal diameter is about sixteen lines in the fifth week, about two inches in the eighth week. Transverse diameter increases from about twelve to twenty-one lines; its weight to about two ounces. The flocculi of the chorion increase but unequally, especially where they extend to the membrana reflexa; they are shorter and more isolated, on the contrary, upon the superior and free side of the chorion. During this period the amnios increases more rapidly than the chorion. The umbilical vesicle is some lines in length and full of fluid.

* Burdach. † *Ibid.* p. 333. ‡ *Ibid.* p. 334.

* Burdach, p. 335. † *Ibid.*

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The embryo increases gradually from three to five lines in the fifth week;* it reaches seven lines in the sixth week; nine lines in the seventh week; twelve lines in the eighth week. Its weight is about a drachm. Up to this period it has been in a horizontal position, the ventral surface facing upwards; it now takes a vertical position, seeing, on the one hand, that the head and upper part of the body descends on account of the increase of their weight; and, on the other, that the umbilical sheath, which is inserted near the inferior extremity of the trunk, becomes lengthened, so that the embryo, already very much curved, is found suspended as by a pedicle.

The height of the head equals at first nearly half the whole length of the body; towards the end of this period it is scarcely a third of the same.

The spinal marrow resembles at first a transparent canal full of a whitish fluid, and the brain a series of vesicles analogous to that canal.

The face begins to appear,† but remains very small in proportion to the cranial cavity. The eyes increase with rapidity and become proportionally very large, the increase of the head in width carries them forwards; they are placed a little above the mouth.

At first there are merely two lines very slightly marked, the one superior, the other inferior, which distinguishes them from the rest of the surface; towards the eighth week the lines are converted into cutaneous folds, rudiments of the eyelids, during which we perceive in the internal angle the opening of the nasal canal and caruncula lacrymalis. The iris is a blackish ring, at first open within and above, formed during the seventh week, but which remains more narrow at that spot. The buccal cavity appears as a close vesicle situated below the brain, and comprehending in it the rudiment of the nasal cavity. In the sixth week this vesicle opens externally by a small fissure, which is the mouth. This fissure increases with rapidity, so that at seven weeks the mouth occupies the whole width of the face; after which, in the eighth week, it becomes limited by small cutaneous folds which are the commencement of the lips.

By degrees the nasal and buccal cavities are separated one from the other, because the palatine apophyses of the superior maxillary bones are developed from before to behind, and from without to within; whilst between them the uvula grows from above downwards, at first consisting of two lateral halves, which however soon unite. In the seventh week the tongue appears, and is soon completely developed. The lower jaw is composed of two lateral halves, and is horizontal without rami.

The nostrils appear towards the seventh week in the form of small fossetees, separated by a thin partition; towards the eighth week the nose appears as a little swelling. During the sixth or seventh week the trunks of the auditory passages appear as small points, the internal ear is developed afterwards. During the seventh week the limbs appear first as little nodules, and by the eighth week have acquired two lines in length.

*Fourth period.*—During this period, which embraces the third lunar month, the umbilical vesicle disappears, and the placenta is formed as an envelope to the fœtus. The principal organs are already developed, and the accessory organs are produced from them. The solid parts have acquired a great part of their configuration, producing a more abundant secretion. Different plastic organs are developed, for instance, at the extremities, and in the sacciform dilatations of the digestive system, the salivary glands to the mouth, the spleen to the stomach, the pancreas at the commencement of the small intestine, the cæcal appendage to the large. The thymous gland appears in the chest. The increase of secretion is manifested by the contents of the gall-bladder and intestinal canal, by the fat which is deposited, by the great quantity of fluid which permeates all parts of the body. But while nutrition is making such rapid progress, the sensorial organs are closed partly by the union of the parts which cover them, and partly by the formation of special tegumentary portions.

*Fifth period* comprehends the fourth and fifth months. The inequality of growth of the organs ceases, approaching more and more to the proportions which they ought to preserve. The purely human form becomes more apparent, the sexual difference is more pronounced; in the brain and spinal cord there are distinct fibres, the muscles become red and fibrous, ossification proceeds rapidly, the teeth become bony, and the nails horny. The embryo moves, and the sensorial organs open.

*Sixth period.*—During this period, which comprehends the sixth, seventh, and eighth months, the developement proceeds, but without any marked changes taking place; but the embryo is now able to exist when separated from the body, though for a very short time.

*Seventh period* comprehends the ninth and tenth months of pregnancy. The vitality of the fœtal placenta diminishes, the circulation in the lungs becomes more strong, and the heart is disposed more and more to the separation of the circulations, the embryo is prepared to quit the body of the mother, and will continue to live if separated from the parent.

### *On the Mammary Organs of Mammals.*

The mammary glands exist only in the mammalia, the highest class of animals, of which they form the principal distinguishing character. Their use is to provide nourishment suitable for the young animal, which is in every instance, for a time of less or greater duration after birth, incapable of preparing nutriment from such matters, either vegetable or animal, as at a future time it is destined to feed upon. Two remarkable instances of the same condition, that is, of incapacity to derive nourishment from that which is to be the animal's subsequent food, and the provision of compensation, are well worthy of notice here. In birds, the interesting observations of Mr. Hunter * on the crop of the nursing pigeon show that, not merely in the female but also in the male, the coats of the crop, which, when the birds are not sitting, are thin and membranous, become, about the time that the young are ready to break their shell, much thicker, assume a glandular appearance, and secrete a substance which, "whatever may be its consistence when just secreted, most probably very soon coagulates into a granulated white curd:" upon this, which is in fact pigeon's milk, the young pigeon is entirely fed till the third day, at which time some of the common food is mingled with it; and as this is gradually increased, so diminishes the secretion,

* Burdach, p. 337. † *Ibid.* p. 338.

* See his paper *On the Secretion in the Crop in breeding Pigeons for the Nourishment of their Young*, in his *Observations on certain Parts of the Animal Economy*, p. 235.

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till at last it ceases entirely, and the young one is fed on its ordinary food; with this difference, however, that it has been softened by being moistened in the juices of the parent's crop. Among insects also it is proved that bees feed their larvæ, during the time required for their change to perfection, when they are confined in their waxen chambers, upon honey, which has previously been elaborated by digestion from the sweet juices of plants, upon which in its perfect state the bee feeds. Such examples easily lead up to the developement of more perfect organs for providing food easy of digestion for the young animal, as presented by the mammary glands in mammalia, which provision of milk is called lactation.

There can be no doubt of the connection between the mammary and reproductive organs. Till the latter have acquired their functional power, the former are merely rudimental, and in many cases exhibit little difference between the two sexes. But so soon as the reproductive organs are capable of their peculiar action, simultaneously do the mammary glands begin to appear as female characteristics. When impregnation has taken place, their developement becomes more evident; and as gestation draws to a close, they commence their office of secreting milk for the support of the young animal, till it is able to feed itself and digest the accustomed food of its race.

The number of mammary organs varies very considerably in the different orders of mammals: in the human female two only exist, which are placed on the fore and lateral parts of the chest, and are specially known as *breasts;* whilst in brutes the same organs are commonly called *dugs* or *udders*. The monkeys, bats, dugongs, and their allied kinds, have the same number and in the same position as the human female. The genera of the family of Lemurs have some two, others four mammary organs, which, from their position on the chest, are called *pectoral*. Among the Pachydermatous, or thick-skinned order, the elephant has two pectoral dugs, the mare has two in the groins, which are then called *inguinal*, whilst the sow has so many as ten, some of which are pectoral, and others upon the belly or *ventral*. The gnawing animals have from two or four to twelve, which are placed either on the chest, belly, or groins. The greatest number, however, are found in the shrew, which has sixteen. Carnivorous animals have them both on the chest and belly. The marsupial order are also furnished with from two to fourteen, which are placed within the pouch, and upon which the young fœtuses are attached and developed. From the appearance of the duck-billed moles of New Holland, and from the usually received opinion that they are oviparous, it was held that they had no mammary organs. Oken however, and subsequently Blainville, conjectured that they would be discovered, and the discovery actually took place and was announced by Meckel in 1824, in Froriep's *Notizen aus dem Gebiete der Natur und Heilkunde*, vol. vi.

The most simple kind of mammary organ seems to be that of the porpoise, *Delphinus Phocæna*, which may perhaps be held as the type of this apparatus in the cetaceous order. According to Professor Baer's account,* the dugs, placed one on each side of the mesial line of the body, between the abdominal muscles and the *panniculus carnosus*, are about eighteen inches long, and are provided each with a single aperture, which is close to the pudendal vestibule. Their walls are so thin, that uncoloured wax which has been injected is readily seen through them, and their cavity is very spacious. A middle canal is distinguishable about the size of an eagle's quill, with wide lateral branches, which again branch out and terminate in obtuse blind extremities. These ramifications, by no means numerous and still less conglobate, lie in an expanded plane between the muscles already mentioned. The walls of the terminations of the branches are indeed somewhat thicker than those of the trunk, but so very little that, in detaching the *panniculus carnosus*, the whole gland may be removed without our being aware of its existence unless previously injected. With regard to this structure, Müller * however thinks, from the examination he has made of the porpoise, that Baer's cœca are really the larger lactiferous ducts, and that the mammary gland is no less complicated in cetaceous than in other animals.

The mammary organs of the *ornithorhynchus* described by Meckel differ, in Baer's opinion, but little from those of the porpoise, except in having their walls thicker. Owen, however, considers this structure in the duck-bill mole more complicated: he says that "each gland consists of from one hundred and fifty to two hundred elongated sub-cylindrical lobes, disposed in a flattened mass, and converging towards a small oval areola, about three or four inches in front of the cloaca, and about an inch from the mesial line of the abdominal integument. These orifices are too small to admit the admission of the smallest absorbent pipe, but will allow the escape of mercury if that be thrown into the larger extremities of the globules, which are minutely cellular. These cells become elongated towards the centre of the lobule, and as it grows narrower form minute tubes, which tend towards and terminate in a large central receptacle from which the excretory duct is contioned."†

The true structure of the glandular part of the mammary organ appears to have been discovered by Cruickshank, and made public by him in 1790. Müller gives, however, the discovery to Duvernoi, in his *Anatomy of the Hedgehog*, published in the *Commentar. Academ. Petrop.*, vol. xiv. p. 199; but his account is by no means so satisfactory as Cruickshank's, that "the acini are small *vesicles* like Florence flasks in miniature; in these the arteries secreting the milk terminate; and from these the excretory ducts, or the tubes carrying off the milk, take their origin."‡ In addition to this statement, Mascagni, in his great work, *Prodromo della grande Anatomia*, 1819, showed the vesicular extremities of the lactiferous tubes, and the absence of all direct communication with the blood-vessels.

During the year 1840 appeared the laborious and magnificent work of Sir Astley Cooper, on the *Anatomy of the Breast*, in which is given a very excellent description of the structure of this important organ, which proves the cellular arrangement of the secreting part of the breast.

The breast consists of an assemblage of glandules and their ducts conglomerated together; and hence it is called a conglomerate gland. These glandules,

* *Noch eine Bemerkung über die Zweifel welche man gegen die Milchdruse des* Ornithorhynchus *erhoben hat und, &c.*, in Meckel's *Archiv für Anatomie und Physiologie*, 1827, p. 568.

* *Physiologie*, p. 424. † *Phil. Transact.* 1832, p. 522.

‡ See his *Anatomy of the Absorbing Vessels in the Human Body*, 2d Edit. p. 209.

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which vary in size from that of a pin's head to a small tare, when unfilled are of an oval form, more pointed at their base, and connected by fibrous membrane. When minutely injected, they are found to be made up of numerous cellules, which are the milk cells; and in proportion to their number is the size of each globule. Of the cellule itself the "size in full lactation is that of a hole pricked on paper by the point of a very fine pin:" it is oval rather than round, in consequence of the springing out of the branch of the milk tube to which it gives origin. Into these cellules the milk is secreted by the arteries which ramify very minutely around them, and from them it is forced forwards, Sir A. Cooper considers, by two causes: 1st, the mere elasticity of the cellule itself; and 2dly, the vis a tergo of the continued secretion into the mammary ducts, which, at first small, gradually coalesce again and again, and as they diminish in number increase in size, till at last they form the trunks of the *mammary* or *milk tubes*, which pass forwards, and before entering the nipple again coalesce in bundles of five or six to form the *reservoirs*, which are of a conical shape. In the human form all these enlarged canals are not so largely developed as in brutes; in many of the ruminant animals they are of great size, and in the cow especially, capable of holding at least a quart of milk and even more. Having reached the nipple or teat the tubes again diminish in size, becoming smaller and smaller as they pass through till they open externally by apertures varying in size, some only capable of admitting a bristle, while others will receive a large pin, although the *mamillary* or *straight tubes* (as these portions of the ducts are called from their position in the nipple, and from their direct course through it) within the nipple are sufficiently large to allow the passage of a probe up to the orifices. As to the number of orifices in the nipple, Sir Astley says the greatest number he has counted in the human female is twenty-two, but the greatest number through which he has been able to inject the milk tubes, twelve, the number more frequently varying from seven to ten. The number of orifices, and of course the number of their corresponding tubes, varies according to the observations of Sir Astley in different animals; the cow, ewe, goat, guineapig, and porpoise have but one tube in each teat; whilst the pig has two, the rhinoceros twelve, and the hare, rabbit, cat, and bitch several.

As to the nipples or teats, which correspond to the number of breasts or dugs, they become filled or erected at the time of suckling in proportion as the milk tubes within them are distended. In most brutes they are distinctly visible. But in the porpoise they are concealed in a cleft on each side the pudendal aperture, and are very minute; and Professor Baer says, even "at the time of heat are not much more than a line in length and scarcely a line in width: thus as at the time of suckling they are not sufficiently large to fill the suckling's mouth, perhaps the lips must be closed laterally on each other, whilst the tip of the mouth only receives the teat."* The duck-billed mole has not however any nipple; the milk tubes terminate as already mentioned upon the abdominal surface near the cloaca; and Mr. Bennet states that "the fur is not even invariably found quite rubbed off at the situation where the ducts of the glands have their termination."* It has been thought that the form of the mouth of the adult animal is ill calculated for suction or application to a flattened surface; but Mr. Owen observes such form "is peculiar to that period," that "the tongue, which in the adult is lodged far back in the mouth, advances in the young animal close to the end of the lower mandible," and that all the increase of the jaws beyond the tip of the tongue "occurs subsequently," and that "the mandibles are surrounded at their base by a thin fold of integument, which extends the angles of the mouth from the base of the lower jaw to equal the breadth of the base of the upper one, and must increase the facility for receiving the milk ejected from the mammary *areola* of the mother."†

*Of the Milk.*—The milk, which is the natural secretion of the mammary organs, is of a white colour, dependent on the presence of numerous *oily globules*, which can be entirely removed by filtration, so that the fluid part of the milk remains clear and transparent. Under ordinary circumstances, if the milk be left at rest for some time, a large portion of the oily globules rise to the surface and form *cream*, which, when skimmed off and dried, forms cream cheese. The remaining fluid after a time, according to the temperature, becomes sour as it is called; undergoing a chemical change, by which an acid, called *lactic acid*, is produced, and a precipitation of *curd*, or *cheese*, takes place, leaving a thin fluid, the *whey*, commonly so called, from which, if slowly evaporated, a quantity of sugar is obtained. The whey, however, does not consist only of sugar and water, but still retains in it both cream and cheese, which require some chemical treatment for their perfect removal; and, indeed, when left alone, small quantities of cream continue separating for many days.

The cream in cows' milk varies from one-eighth to one-fourth, but more commonly the former; whilst in that of the human female it is from one-fifth to one-third. The specific gravity of milk is 1·024; and, according to Berzelius, it consists of—

| | |
|---|---|
| Butter . . . . . . . | 45 |
| Cheese . . . . . . . | 35 |
| Sugar of milk and saline ingredients, viz. a free acid, lactate of iron, acetate of potass, chloruret of potassium, phosphates of lime, magnesia, and potass . . . . | 44 |
| Water (buttermilk?) . . . . | 876 |

When cream has been beaten in a churn it separates into two parts, *butter* and *buttermilk*. The butter contains about a sixth of its weight of caseous and other matters which may be separated from it by careful fusion. When thus purified it is found to contain, not only oleine and stearine, but also a fatty matter peculiar to it called *butyrine*.

The composition of skimmed milk, or that from which the cream has been removed, is, according to Berzelius, in 1000 parts, at a specific gravity of 1·033,

| | |
|---|---|
| Water . . . . . . . | 928·75 |
| Caseous matter, with traces of butter . | 28·00 |
| Sugar of milk . . . . . | 35·00 |
| Lactic acid, acetate of potass, and traces of a salt of iron . . . . | 6·00 |

* See his paper in Meckel's *Archiv. ut supra.*

* See his paper *On the History and Habits of the Ornithorhynchus Paradoxus*, in *Zool. Trans.* vol. i. p. 231.

† See his paper *On the Young of the Ornithorhynchus Paradoxus*, in *Zool. Trans.* vol. i. p. 223.

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Zoology.

| | |
|---|---|
| Hydrochlorate and phosphate of potass | 1·95 |
| Phosphate of iron | 0·05 |

The caseous matter of milk, or *casein* as it is called, from its being the basis of cheese, is white, insipid, and inodorous, insoluble in water, but very soluble in the alkalies. It resembles the albumen of the blood in being precipitated from its solution by alcohol, but it differs from it in being coagulated by acetic acid. In the human female it separates much more slowly than in cows' milk. According to Gay Lussac and Thenard, the purest casein consists of—

| | | | |
|---|---|---|---|
| Carbon | 59·78 | Hydrogen | 7·43 |
| Oxygen | 60·41 | Nitrogen | 21·38 |

It quickly undergoes putrefactive fermentation when kept moist, producing, as Prout states, two substances, *caseic acid* and *caseous oxide*; or, according to Braconnet, chiefly a matter called *oposepodine*.

The *sugar of milk*, which is obtained in small brown crystals by the evaporation of whey, consists of—

| | |
|---|---|
| Carbon | 45·94 |
| Hydrogen | 6·00 |
| Oxygen | 48·06 |

It is obtained in Switzerland in large quantities from the whey after cheese-making, and is used by the peasants for all the purposes to which cane-sugar is applied in this country. It has long been known that a spirituous liquor called *koumiss* is obtained by the Tartars from mares' milk; notwithstanding which, it has been said to be incapable of vinous fermentation. Fless, however, has proved that sugar of milk is capable of conversion into alcohol by fermentation, although with less readiness than the juice of the sugar-cane or grape.

Milk is not alike in all animals: in some it is more rich in butter, whilst in others the albumen predominates. The kind of food which the animal takes has, doubtless, considerable influence upon it: thus, in those which feed on flesh, the milk is more serous than in such as feed on vegetable substances. But there is a further difference, even in those animals which feed on the same kind of aliment: thus, the milk of the cow yields much cream, whilst that of the sheep and goat produce little. Whilst, on the other hand, if the milk of the human female be compared with that of the female ass, or of the mare, considerable resemblance is found among them, although nourished on so different food. It is also well known that the flavour and odour of milk is affected by the food: thus, the butter made from the milk of a cow fed on turnips is so strongly affected with the peculiar taste of that vegetable as to be very offensive. And in Ireland, where the cattle are fed upon fish, the milk has a very disagreeable odour. Its colour is also affected: thus, butter is reddened by feeding with madder, or tinged of a deep golden colour by the use of saffron.

Though suckling is the natural and special duty of the female, yet is it a well ascertained, as well as a very interesting fact, that the male, not only of brutes, but of the human kind, has occasionally given suck. The following are among the instances of such vicarious function in brutes. A lamb belonging to Sir William Lowther, having lost its dam, attached itself to a wether, "and brought him to milk, and was maintained by him all the summer: he had two considerable teats on his udder, each side whereof was about the bigness of a hen's egg."* Blumenbach also mentions an instance of a he-goat which required milking every other day for a year.†

The practice of male nursing is not uncommon in some parts of Europe. Lalymann says, "This is by no means rare in Russia at the present time, where the practice of inspecting bodies has been introduced. For I have noticed that the nipples of almost all men yield upon slight pressure a juice sometimes milky and other times serous many days after death, notwithstanding the coldest temperature."‡ And Bartholin mentions§ numerous instances of milk furnished by the breasts not only of virgins but also by those of men; and in one instance he states, on the authority of Abensina, that so much milk was produced from the breast of a male as was sufficient to be converted into cheese, and in another case, on the testimony of Lantorelli, himself an eye-witness of the fact, a Calabrian on the death of his wife, being unable to obtain a nurse, brought up his child at his own breast. Precisely similar is the curious instance mentioned on the authority of Mr. Wenzel, of which the following is a brief extract:—The wife of a young Chipewyan in her first pregnancy, whilst out with him on a hunting expedition, was taken in labour and died on the third day. The husband, in deepest anguish, vowed never to take another wife, but himself tended to the infant, wrapping it up warmly, feeding it with broth, and, to still its cries, placing it to his breast, and praying earnestly to the great Master of life to assist his endeavours; a flow of milk actually took place, and he reared his child. And what was still more curious, the left breast, even in his old age, retained the unusual size it had acquired in his occupation of nurse.‖

### Animal Functions.

#### *Sensation and Motion.*

Although the functions of nutrition and reproduction are common to plants and animals for their support and continuance; yet are the substances built up by these living beings widely different from each other, the plant being incapable of performing the functions of sensation and motion, which alone belong to and indeed constitute the animal, and are therefore called *Animal Functions*.

It might naturally be expected, and indeed (except in the very lowest animals) can be easily shown, that there is no immediate and striking difference between the compounding (if it may be so called) of the elemental matters, of which the substance of a plant or of an animal consists, and hence the division into *Vegetable and Animal Matter*. Of the elemental substances entering into the composition of both plants and animals, notice has been already taken; from which it appears that plants consist of nineteen elements, whilst in animals but sixteen of them are found, the other three, aluminium, gold, and copper, not having been yet discovered. It is not, however, to be supposed that the disposition of vegetable matter in a plant, or of animal matter in an animal, is one and the same throughout each individual, but each really consists of differently arranged and differently composed structures, which are combined in

* See *Philosophical Transactions*, 1694, p. 263.
† See *Hannoverisch Magazin*, 1787, p. 755.
‡ See his *Observationes Anatomicæ* in *Commentar. Acad. Scient. Imper. Petrop.* vol. iii. p. 279.
§ See his *Anatome*, p. 334.
‖ See Capt. Franklin's *Journey to the Polar Sea in the Years* 1819, 20, 21, and 22, p. 157.



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various modes and with variety of complication to form *organs* for the performance of required functions. These various structures then are the materials of which both the vegetable and animal organs are formed, precisely as wood, iron, or other material manufactured into shafts, rods, wheels, screws, bolts, &c. are arranged and connected so as to produce the various complications of machinery.

As the functions now about to be treated of are peculiar to animal being, it would seem most advisable before entering upon their consideration to give an account of the various structures which animal bodies present. Some of these structures are necessary to the very existence of an animal, whilst others are required only for the due performance of the peculiar functions or habits of that class to which the animal belongs, and though found in one are not met with in another animal. To these structures, from their web-like disposition, the term *Tissue* has been applied.

### *Of the Animal Tissues.*

Anatomists have divided the tissues into classes, varying in number from eight to twenty-one. It would seem, however, that strictly speaking there is but one primary or generating tissue, the *cellular*, which may exist in the body either as a distinct tissue, or with the addition of other organic matter may produce three *secondary* tissues, viz. the *nervous* and the *muscular*, from whence result the animal functions of sensation and motion, and the *vascular*, by which the organic functions of nutrition, secretion, and excretion are performed. All these tissues, with the exception of the muscular, are found in the remaining or tertiary tissues, viz. horny, ligamentous, bony, &c. the peculiar characters of which depend upon the presence of other substances.

### Of the Cellular Tissue.

*Tela Cellulosa*, Lat.; *das Zellgewebe*, Germ.; *le Tissu Cellulaire*, Fr.

The universal extension of the cellular tissue throughout the body, its large participation in the structure of every organ, including even its most minute parts, and the almost general opinion of anatomists that it is the first developed of the tissues which build up the corporeal fabric, demand, whatever may be the subsequent arrangement, that this, the groundwork of the whole, or as it is often called, the Generating Tissue, should be first considered. Accordingly, after enumerating those substances which in his time were considered the elements of the human body, and after defining his ideal fibre and lamina, which in no respect differ from the mathematical line and superficies, the illustrious Haller proceeds, in his *Elementa Physiologiæ*, to describe the *Tela Cellulosa*, or cellular tissue, and the same course has been generally followed by systematic writers on Anatomy.

The cellular tissue may be defined as—

A semitransparent soft spongy substance, consisting of an infinity of extremely minute threads passing in every direction, anastomosing (not interlacing) with each other, and leaving between them innumerable irregular spaces, cells, or areoles, for the most part freely communicating with each other, and in which are contained vapour, fluid, and fat.

In this form, and often with the fibres or threads matted together so as to form a kind of plates, the cellular tissue is expanded over every part of the body, dipping between the organs and their several parts, and directly or indirectly connecting them throughout as the fluid in a galvanic battery connects the several plates.



*Anatomical characters.*—The cellular tissue, in its purest state and entirely free from fat, is found in the scrotum, connecting the skin with the vaginal tunic. If a portion of it from this part be gently raised, it presents the appearance of a confused mass of thread-like fibres running into one another in every conceivable direction, and bearing a very close resemblance to the well-known delicate intersecting webs which some insects form during their caterpillar state among the twigs of hedges, to serve them as ready transits from one twig to another; and were this web detached from the shrub on which it is expanded and allowed to fall together, it would present a good illustration of the cellular tissue when undisturbed.

In consequence of this disposition of the fibres, interspaces exist between them, small and minute indeed, and without determinate figure, but still distinct spaces, to which the name of *cells*, *areoles*, and *vacuoles* have been applied by different writers. It is not, however, intended to describe them as being cavities with perfect partitions except at the points where they communicate with each other, they are no more than such cavities as would be produced by the transit of numerous threads in varied directions through any portion of space, which thus divided, would be said to have a cellular character; the sides of such cavities are open in every part excepting where the threads pass or meet, and form the outline or skeleton of the cell or cavity. Neither is it intended to compare the cavities in the cellular tissue with the cellular structure of plants, in which the threads forming the outline of the cells are stiff, and the cell which is closed retains always its usually angular figure. But in the cellular tissue of animals the fibres forming the cells, when undisturbed, lie upon one another like the detached caterpillar web already mentioned, or like the several locks in a flock of wool; the spaces still remain though altered in form, and apparently non-existent till the threads are drawn asunder, or in some other way separated, when the interspaces are rendered visible. The free communication of these cavities is well seen in the common practice adopted by butchers to give transparency and plumpness to veal and lamb; prior to skinning the animal, they make an aperture through the hide where most loosely attached to the subjacent flesh, and then with little difficulty inflate the whole cellular tissue immediately beneath the skin, and as the tissue soon dries by exposure to air, its fibres becoming stiff leave the cellular structure very apparent, as may be easily shown by making a section with a sharp knife. Similar proofs of the free communication of these cavities occur also in the human body under accident or disease; a person receives an injury by which a rib is broken; its fractured part is thrust into and wounds the lung, through this wound the air escapes into the cavity of the chest, and at every inspiration is forced out into the cellular tissue which has been also wounded by the broken rib; here it quickly spreads from cell to cell, and often expands the skin to its utmost extent, so that it seems ready to burst. So again in general dropsy, the fluid contained in the cellular tissue is seen gravitating from one part to another, according as one or other is most dependent.

The existence of cells or cavities in the cellular tissue has long been subject of dispute among anatomists; Haller, De Bergen, Scubinger, Hill, Hunter, among

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the writers of the last, and Bechat, Beclard, Blainville, and Müller, amongst those of the present century, hold with the cellular structure of this tissue, whilst Wolff, Meckel and others totally deny it, as we shall presently see.

Wolff* was the first writer who disavowed the existence of cells in the cellular tissue; he says, "If you examine the cellular substance with assisted or unassisted eyes, you nowhere find in it cells, or pores, or cavities, or plates containing cells, or broad leaves, or threads with distinct interspaces, (however we may have been accustomed to consider it as cellular, and as it is commonly taught and shown,) except you form it into threads or plates by pulling apart before you examine it." And he continues a little further on: "Everywhere I have found a continuous semifluid, adhesive, or connecting substance; cellular I have never seen." He endeavours to explain the fibrous appearance of the cellular tissue by stating the well-known fact, that if any semifluid tenacious substance be pulled apart, it does not at once separate, but, that as the particles are torn from one part they collect at another, and thus form threads, passing from one to the other portion, which, as the extension is continued, elongate, become thinner, and at last snap asunder and produce the total division of the tenacious mass; and thus "this semifluid and tenacious substance," which everywhere glues the adjoining fibres together, if the fibres be separated, "is extended into threads or plates, and into cellular membrane." He accounts for the free passage of air, water, or other fluids in the cellular tissue by supposing after they have been once introduced into it that they form bubbles, just as the air bubbles are produced in soap and water, or any other tenacious semifluid substance, and in this way accounts for the production of anasarca and emphysema. But this comparison, though very ingenious, is not correct, for when air is injected into soap and water, or any other similar substance, the bubbles so formed cannot be dissipated except each single bladder be broken; on the contrary, in anasarca and emphysema, the water or air is readily discharged from the whole swollen part, for instance the arm or leg, merely by one or two small punctures, which could not be the case, unless the several vesicles, even if formed as Wolff supposes, communicated, which according to his idea they could not, but which is the only way in which the escape of the water or air can be accounted for, viz. by the free communications of the cells or interspaces throughout the whole cellular tissue. His objection, however, to the journeyings of extraneous bodies, as needles, thorns, shot, &c. through the cellular tissue, often mentioned as proof of its cellular structure, is just, for "how can a musket-ball creep through the cells, pass in and out of their orifices and the apertures by which they communicate, being ten or a hundred times larger than the cells themselves."

Bordeu † is generally considered to have denied the existence of cells in this tissue, or *Tissu Muqueux* as he calls it, and which he describes as "a kind of viscum *(bave)* or glue, of which the parts elongate to a certain point in proportion as we separate the fibres; (*le plus petit faisceau de fibres qu'il soit possible d'examiner;*) this glue (*colle*) forms the cellular tissue, taken in its commencement; or rather this glue is *but a portion* of the cellular tissue." He does not, however, deny the existence of cells, but only their determinate form. As, however, it is on his authority (though as we have just seen Wolff first taught the doctrine) that those who deny the existence of cells rest, it will be worth while to give the whole passage, that it may be seen what he really does say in reference to this point. "This substance has derived its name from the *cells seen in its interior;* we do not, however, mean to say that it is very easy to perceive these *cells;* they are not, as we might suppose, similar to little bladders which open into each other; they have no regularity, no symmetry, and we may compare them to the spaces (*intervalles*) which occur in heaps of wool or flax. In order to obtain a correct idea we must examine them, which will teach more than all we can say. In separating two adjacent fibres from each other, we develope or rather produce an immense number of small mucous filaments which are parallel, and leave between them *some little spaces.* These spaces were the points in which the fibres touch directly, or at which there is scarcely any glue, (*colle,*) but these little spaces are never in the living subject such as in two fibres which we separate from each other; *they exist, however, and form the first cellules of the tissue.*"* Again, after stating that every fibre is ensheathed in its mucous covering, (*chaque fibre est engainée dans sa couche de* MUCOSITÉ,) that two or three of these are enclosed in one general sheath, and that there are consequently *primitive* and *secondary* layers of cellular tissue, of which the former are very soft and the latter more tough, more membranous, he says that "the *porous* sheath of each fibre joined to those of the neighbouring fibres and the three *sheaths* themselves surrounded by a common sheath, of which the interior is glued to the three proper ones, are but a kind of *spongy body,* in which there are *cavities* varying according to the greater or less motion and separation of the fibres."† From these extracts it will be seen that Bordeu, whatever his disciples may please to say for him, does not deny, but on the contrary admits, the existence of cells, though of indeterminate form, and speaks of two distinct components of cellular tissue, *fibres* and *mucosité.*

Meckel's opinion of this tissue, which, with other writers of the same views, he calls the mucous or cellular system, (das *Schleim System,* oder *Zell System,*) corresponds pretty much with that of Wolff. He considers it "as the coagulable fluid (one of the two ultimate organic elements) in a state of coagulation;" he denies its fibrous and cellular disposition, and says "that on closer inspection this opinion is at least too general, and that the mucous tissue is rather a cohering, viscous, homogeneous, scarcely solid, formless substance."‡

*Microscopic characters.*—Within the last few years anatomists and other microscopic observers having been anxiously employed in repeating the inquiries of Leeuwenhoek, Muys, and Fontana, after the elementary forms assumed by the different tissues of the body, the cellular tissue has not been neglected. Milne Edwards states that it "is entirely formed of globules united in irregular series, which present nothing constant in reference to their position, or that of their apparent length. These series form lines sometimes more or less tortuous, sometimes straight or slightly curved, of which the

* Wolff, *De Tela, quam dicunt Cellulosa, Observationes* in *Nov. Act. Petrop. Acad. Imper.* vol. vi. p. 259.

† Bordeu, *Recherches sur le Tissu Muqueux ou l'Organe Cellulaire.* Paris, 1791, p. 2.

* Bordeu, *loc. cit.* p. 5. † *Ibid.* p. 7. ‡ Vol. i. p. 116.



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direction and relative situation vary for almost every one of them. These globules thus disposed in rows do not form a continued plane but appear placed in successive layers, so that the interstices which occur between the rows of globules placed on the same plane permit us to see the series forming the following layer; and the gaps of the latter are in their turn in relation with the kind of globular network of an inferior layer."* Thus "the arrangement of these different layers of globules account for the permeability of the cellular tissue, and explains how the plates, without being perforated, allow the rapid passage of liquids with which they come in contact." He also states that from careful examination he found all the globules of the same size, and their diameter to measure $\frac{1}{300}$th of a millimeter.†

Treviranus has within the last few years given two highly interesting papers on the ultimate structure of cellular tissue, in which he describes the existence of *elementary cylinders* as he calls them, which there seems little doubt are the "fibres of Bordeu." In his first paper he describes them "as very delicate, transparent, serpentine cylinders, between those globules which had the appearance of albuminous globules, and a semifluid matter enveloping both parts;"‡ the *fibre* and *colle* of Bordeu. They are visible with a magnifying power of 150 diameters or even less, in most cellular tissue, but require to have been previously examined with one of 300 diameters, in order to make them out satisfactorily to an unpractised eye. "We observe them," says Treviranus, "under a simple lens, not indeed single but in bundles, forming a retiform tissue, the *corpus cribrosum* of the old writers, the threads of which consist of elementary cylinders twisted together."§ After having been for some time macerated in spirit these cylinders assume the same appearance under a weak lens as a hank of hair floating in water does to the naked eye. The opinions of Treviranus in the interval between the publication of his first and second papers must have changed, although he makes no such acknowledgment in the latter. In the first paper he says, "I have found Wolff's and Rudolphi's observations entirely consonant with truth. All animal cellular tissue appears to me as a mucous-like substance, which by extension spreads into a membrane." In the second he observes, speaking of the elementary cylinders,|| "but mucus drawn out into threads they are not. This substance never forms such delicate and still less such contorted threads as are comparable with the elementary cylinders. Somewhat greater resemblance to the latter have the streaks, (*streifen,*) seen under the microscope, in mucus which has been first dried and then wetted. But these are mere canals (*gange*) in the viscous fluid unsurrounded by any proper membrane; on the contrary, the elementary cylinder is formed of a peculiar membrane, of which we may be convinced, if we carefully examine the edges of a piece of cellular tissue lying in water. We always there find the cylinder projecting distinctly over the boundary of the tissue, and often very much beyond it."¶ And shortly after, in a subsequent part of his paper, he says, he shall show that these elementary cylinders "in some intestines pass from this state of great delicacy into another where they possess all the true characters of tubes."* From this statement it is obvious that Treviranus, as well as Bordeu, admits into the composition of his cellular tissue something more than the *mucosité* or mucous-like substance, that the latter calls this *fibres*, and the former *elementary cylinder;* but as to what the contents of this cylinder consist of, Treviranus does not commit himself to an opinion, though it is probable that in the cellular tissue it consists of the same formless semifluid matter by which it is surrounded. It is due, however, to Treviranus to mention that he states, "These cylinders have been long noticed by other observers. But they were sometimes confounded with forms which are seen only when the microscope is improperly used, sometimes considered to resemble things with which they have nothing in common, and that sometimes they are modelled after preconceived opinions."† By which he refers to the observations of Leeuwenhoek, Fontana, Mascagni, and Edwards. The most recent observer of cellular tissue is Jurdan; he describes its elementary parts as consisting of "fibres transparent, clear as water, slightly serpentine, capable of being made straight by polling, extremely delicate, and of equal thickness throughout their whole length, and not consisting of globules. By microscopic measurement I found their diameter varying from 0·0005 to 0·0009 of an English line, but in the greater number it was 0·0007."‡ These primitive fibres are either collected together "and form secondary fibres which cross variously and thus form a retiform tissue, sometimes loose at other times close, or they cross and form very thick and very delicate plates." He shows that the tissue differs from mucus in having no globules, and that though by boiling it is converted into gelatine, it is not gelatine, because that is a homogeneous fluid, and has neither fibres nor globules. Before concluding this very brief review of Treviranus's opinions in regard to the cellular tissue, it must be observed that he states, "In many parts cavities exist in the cellular tissue which contain fat; and these spaces wherein the fat collects cannot be considered as dilated elementary cylinders, for their walls consist of such cylinders."§ If, then, such hollows exist for the reception of fat, which however, as will be hereafter shown, are distinct and separate cavities, why should there be any difficulty in imagining that the elementary cylinders are to a certain extent separate elsewhere, in order to account for the free spreading throughout the whole structure of the moisture by which it is lubricated, and also to explain the well known fact of the ready percolation of water and air in anasarca and emphysema? From a fair examination and comparison of these writers, we may therefore come to the conclusion that, after all, Haller's opinion about the structure of cellular tissue was not so incorrect as later authors are disposed to make it appear.

The vascularity of the cellular tissue in general is yet doubted by anatomists, although Mascagni's observation of vessels running to those parts of it in which fat is contained is a presumptive proof that vessels also belong to the other and larger portion, in which a lubricating

* Milne Edwards, *Mémoire sur la Structure Elémentaire des principaux Tissus Organiques des Animaux*, p. 7. In *Collection des Theses soutenues à la Faculté de Médecine à Paris*, vol. iii. No. 73.

† Milne Edwards, *loc. cit.* p. 9.

‡ Treviranus, *Ueber die Organischen Elemente des Thierischen Korpers*, p. 125, in *Vermischte Schriften.*

§ *Neue Untersuchungen uber die Organischen Elemente der Thierische Korper, &c.* p. 20.

|| P. 125.

¶ See *loc. cit.* p. 20.

* See *loc. cit.* p. 21.

† *Ibid.* p. 22.

‡ See his Paper, *Ueber das Gewebe der Tunica Dartos und Vergleichung desselben mit anderen Geweben*, in Muller's *Archiv für Anatomie und Physiologie, &c.* p. 419; Berlin, 1834.

§ See *loc. cit.* p. 18.

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vapour exists, and by which that vapour is secreted. And it may further be observed that if, as is known to be the fact, serous and mucous membranes, which truly are no more than closely condensed cellular tissue, are largely provided with vessels, it is also probable that the cellular tissue itself has its own proper vessels, although they may not be discoverable on account of their extreme minuteness and consequent incapability of allowing the passage of red blood whilst in a healthy state. If, however, the tissue become inflamed, these vessels become gorged with blood, and instead of secreting their natural vapour pour out adhesive matter in large quantity, and in a very short space of time. Within the last few years, however, Bleuland has stated that he has discovered these vessels in the abdominal cellular tissue of a newly born infant, that their disposition and arrangement is different from that of the vessels belonging to muscles, and that they secrete both vapour and fat.*

The existence of proper nerves in the cellular tissue is also disputed; and it is generally held that those seen are merely passing to other parts, and not terminating in the tissue itself. Treviranus, however, considers that all nerves terminate in cellular tissue. It is probable that both assertions are too sweeping; for though it be allowed that cellular tissue is supplied with nerves, as it would seem inadmissible to suppose any animal structure without them, yet it is certain that many do traverse the cellular tissue to be distributed to other parts, as for instance to the skin. The analogy between this tissue and serous or mucous membranes holds also as well in regard to the nerves as it does to the vessels; for if, as occurs in injecting a hydrocele, the vaginal tunic, a serous membrane, speedily inflames, and violent pain succeeds, it cannot be doubted that that tunic has nerves, although of very minute size, and therefore it may be presumed that cellular tissue is similarly supplied, especially as, if injected with any irritating liquid, severe pain is soon felt and acute inflammation excited, as for instance in urinary extravasation; nor does this arise from the mere distension of the fibres of the cellular tissue, as neither pain nor inflammation is excited when they are stretched by the extravasation of air in emphysema, or by water in dropsy.

*Physical characters—Colour.* The general appearance of cellular tissue is dull white or grey, inclining to brownish; it is white when heaped up in any considerable quantity, and the light incapable of penetrating is reflected from it; on the contrary it is grey or brownish in proportion to its thinness and small bulk, in which case the light passes through on account of its transparency. The brownish colour, however, seems in some respect to be dependent on the semifluid formless matter by which the cylinders are connected, and this being, according to the observations of Treviranus, of a brownish colour, gives that tint to the spaces between the cylinders, but which may be washed away by dropping water upon it.

*Extensibility.*—It may be matter of doubt whether the cylinders or fibres and plates of the cellular tissue have in themselves any capability of extension, but there can be no doubt that this mass is highly extensible. This depends on the natural falling together of the fibrea and plates when the parts which the cellular tissue connects are at rest. The instrument known to most persons by the name of *Idle Tongs* are perhaps as good an illustration of the extensibility of cellular tissue as can be afforded; when folded up, the numerous diagonal pieces of iron of which they consist do not exceed six or eight inches in length, but when brought into action, their extremities are distanced from twice to thrice of that length. Just so is it with the cellular tissue; the skin all over the body is connected by this tissue with the subjacent parts and seems and is closely connected with them by it; but if in a thin person the skin be pinched up on the neck, arm, or back of the hand, it can be drawn to a considerable distance from the parts beneath it, the cellular fibres and plates being compelled to change their natural diagonal or nearly horizontal position for one nearly vertical. So again if the lungs be wounded and an outlet made into the cellular tissue, the same thing occurs, only with the difference of the extension being made from within instead of from without, and the cellular tissue is as perfectly inflated as a bladder would be, and consequently the position of its fibres and plates altered as in the former case. The extension allowed is so great that often in wounds of the lungs consequent on broken ribs, the body appears swollen at least half its natural size. And in other though more rare cases, where the bony walls of the cavities connected with the nose have been broken and the air has escaped during respiration into the cellular tissue of the face, the whole head has assumed an enormous bulk and very frightful appearance. The same result also occurs in dropsical enlargements from the extensibility of the cellular tissue. Blainville has compared this extensibility to that which a steel spiral possesses; it is a very pretty illustration, but certainly not a true one.

*Affected by atmospheric influence.*—The cellular tissue is a good conductor of caloric, and it is for this reason that persons who are thin feel the alternation of heat and cold more severely than those who are fat. This does not arise from the one possessing a greater quantity of the cellular tissue than the other, but from its fat vesicles in the latter being so distended as to form a kind of tunic which prevents the ready transmission of the caloric through the tissue. And it is one of the reasons why hybernating animals before retiring to their winter sleep always acquire a considerable quantity of fat on the surface of the body. The same also is observable in those warm-blooded animals which are constantly exposed to very low temperatures, either on the earth or in the sea, as the bears and the whole cetaceous order; by which means the temperature of the body is pretty equally preserved.

In some peculiar though not comprehensible manner it is affected by the hygrometrical state of the atmosphere, as is well known to rheumatic patients, who, on the approach of damp weather or the prevalence of easterly winds, become affected with the dull aching pains which belong to that disease.

It is also considered to be a good conductor of electricity, and perhaps from the great extent of the body which it pervades, the free passage of the electric currents throughout the whole frame by its instrumentality may be accounted for; whilst on the other hand the greater sensation felt at the joints when a person is electrified is explained by the cellular communication being less complete there than at other parts.

*Chemical characters.*—Cellular tissue is insoluble in cold water, and undergoes no other change than that of swelling and increasing in bulk by absorption of the fluid,

* See his *Icones Anatomico-physiologicæ partium corporis humani, &c.* Fasc. 1. Tab. vi. 4to. *Trajecti ad Rhenum*, 1826.

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like a sponge dipped in water. If put into boiling water it shrivels up, but is otherwise little affected, except the boiling be continued for a length of time; it then diminishes considerably in bulk and a large quantity of gelatine or gluten is produced. This was formerly considered as an elementary part of the tissue, but chemists now consider it as the albuminous part which has undergone a change by the ebullition. If the gelatine be in quantity it becomes solid as it cools, but if not, can be precipitated by the addition of alcohol. When dried gradually the cellular tissue becomes tough, flexible, and partially transparent, is disposed to absorb moisture readily, and if plunged into water soon resumes its natural character and appearance. If, however, it be exposed to great heat it dries rapidly, shrivels up, as it burns emits a strong ammoniacal smell, and is reduced to a small quantity of ashes.

According to Fourcroy's examination, cellular tissue consists of gelatine; and John states, that it also contains a small quantity of fibrine, together with phosphate and carbonate of lime.

A remarkable character of this tissue is the resistance it offers to the putrefactive process. If freed from other parts which become quickly putrescent, it will remain for a very considerable length of time unchanged, and, according to Bichat, putrefies less easily even than tendinous tissue; a fact which is, however, well known in macerations for skeletons. Experiments made by this anatomist showed that cellular tissue which had surrounded an artery and kept in a glass jar of water, at the common heat of a cellar, for three months, and other which had enveloped a nerve, and kept under the same circumstances for six months, remained unchanged. After longer maceration, however, the tissue is converted into a viscous substance resembling mucilage, and gives out different products which rise to the surface.

*Vital properties.*—As has been already stated, there is much dispute as to the sensibility of the cellular tissue in its healthy state, but of the severity of the pain suffered when it is inflamed there can be no doubt, as daily experience proves. It is not excitable by any stimulus, not even by galvanism, as shown in Jordan's experiment on the cellular tissue of the scrotum with a pile of sixty-five plates. It does, however, contract on the application of cold, and elongate under warmth, as is distinctly seen in the scrotum; how this is explicable does not appear, and Bichat's application of the term *contractilité de tissu* to this property, which he considers independent of vital influence, is little better than concealing our ignorance of the matter by giving it another name.

It possesses in a remarkable degree the power of imbibition, originating in its capillary disposition, in consequence of which it sucks up fluids in which it is immersed, and from its soft and yielding texture becomes swollen by them.

*Distribution of the cellular tissue.*—There is no part of the body over which the cellular tissue does not range, or into which it does not penetrate. Beneath the skin which it connects to the subjacent parts it stretches over all the organs, and dipping into or between them connects them throughout, directly or indirectly. If it were possible to abstract all the other animal matter, a perfect mould of every organ would be presented by the cellular tissue which connects their parts and them and envelopes the whole. In some organs, the nerves for instance, this can be proved, for by chemical aid the nervous matter can be extracted and the cellular tube or mould in which it was contained left perfect.



The cellular tissue, although of the same actual structure throughout, varies in quantity, density, and disposition, according to the office it has to perform. Sometimes it connects parts so closely together as to prevent any intermediate motion; it is then very short, and so blended with the parts it unites that it is difficult to determine them from each other; this is commonly the case in the connection of serous and mucous membranes with other structures. At other times it is in very large quantity, and very lax, so as to admit of considerable motion between the connected parts. This occurs in the connection of the skin to the subjacent parts, especially about joints, where the connection must be very loose to prevent any hinderance to motion. It is loose also where connecting muscles to each other or to neighbouring parts, so that their actions may not be impeded. It may also be in large quantity and much condensed, so as to form broad expanded cellular plates or membranes; such occur specially on the belly, in the perineum, and on the neck; their use is to give support, and they are but little extensile. Such membranes have been loosely named *Fasciæ* and *Aponeuroses*, and thus are mentioned the fascia of the neck and perineum, and the fascia or aponeurosis of the external oblique muscle of the belly and others; but they have no resemblance in structure to *fascia*, (by which in strict anatomical language is meant a tendinous expansion,) for they are made up entirely of condensed cellular tissue. The sheaths of vessels and the capsules of glands are in the same way formed of this condensed tissue, which as it were isolates them from the surrounding parts. The vessel and its sheath are pretty largely and firmly connected by intermediate tissue; but that connecting the gland and its capsule is small in quantity and very delicate, so that when opened, the gland can be turned with little difficulty out of it like a nut from its shell, and the interior of the capsule is seen glistening and almost smooth, appearing to form the transition between common cellular tissue and serous membranes. The external coat of both arteries and veins, perhaps also of the absorbent vessels, and the bulk of the tube of excretory ducts consist of cellular tissue, externally loose and flocculent, but gradually becoming more and more condensed as it approaches the muscular coat of the vessels, or the mucous coat of the ducts. Still more condensed and of more determinate form does it become when under the name of *neurilema* it assumes the shape of minute tubes for the lodgement of the nervous matter, and the production of nervous fibrils: the interior of these are smooth and close, their exterior loose and rough, by which numerous tubes are connected together and form a nerve. In precisely the same way are the fibres of muscle or any other fibrous structure connected, excepting that the cellular investments or tubes are not so largely developed, and the smaller the bundles of fibres be, the more delicate and tender is their envelopes. Bordeu has well described this cellular connection of fibre in the following terms: "We must consider all the layers of cellular tissue belonging to a muscle as circular cases (*ballons*) contained one within the other, which diminish proportionally with the fibres, and become more delicate and tender."* In parts which have not a fibrous form, but consist of

* Bordeu, p. 46.

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Zoology.

granules or globules, as glands, the small parts of these organs are connected by a reticular disposition of the cellular tissue. Cellular tissue is also matted into large plates, one side of which assumes a highly polished and brilliant appearance, whilst the other is rough and flocculent; such is the general character of serous membranes, to which it will be necessary hereafter to revert.

Anatomists have thought it expedient to classify these various arrangements of the cellular tissue. Borden only speaks of it under two points of view, as within and without the cavities of the body; but in one respect his observations are highly interesting, as being the first writer who pointed out the cellular structure of serous membranes. He says, "We cannot help regarding certain membranes, such as the peritoneum, pleura, and some others, as parts of the cellular tissue; these membranes evidently appear to be processes of that tissue, which have been so closely approximated by the neighbouring parts, that they have formed membranes, smooth and polished, especially on that side most subjected to friction."* The concluding part of the sentence is an absurdity, but his statement of the composition of the membranes correct. Bichat divided the cellular tissue into—1. that which is exterior,† and 2. that which is interior to every organ,‡ but his subdivisions are uselessly minute. Beclard divides it into three portions: 1. the external, general, or common cellular tissue, *Textus Cellularis Intermedius seu Laxus*,§ which does not penetrate the organs, but extends throughout, and assumes the general form of the body; 2. the special cellular tissue, which forms both the proper covering of each organ, as the *Textus Cellularis Strictus*,‖ and enters into its substance, following and enveloping all its parts, as the *Textus Cellularis Stipatus*;¶ 3. the organic tissue, *Textus Cellularis Organicus seu Parenchymotis*,** which forms the base of all and the entire substance of some organs. Meckel speaks only of an internal or special, and an external or general cellular tissue;†† and Krause, of an investing or connecting cellular tissue, *Umhüllungs-und Verbindungszellstoff*,‡‡ corresponding pretty much to Meckel's external tissue, and a composing, parenchymatous, or organic cellular tissue, *Zusammensetzende Zellstoff*.§§

It must be remembered, however, that these divisions are merely arbitrary, for the whole cellular mass freely communicates throughout the body; and this is especially seen in the transit of the large vessels from the cavities of the chest and belly into the neck and limbs, in which case they are largely covered by cellular tissue which forms a bed for their support, and at the same time effects a free communication between that part of the tissue within and that without the cavities of the body. In the same manner also is the cellular tissue covering the surface of each organ freely connected with that which enters into its structure, and connects its most minute parts.

*Contents of the cellular tissue.*—The cellular tissue is pervaded by a thin vapour, which when an incision is made through the skin of a living animal, in a cold atmosphere, condenses as it comes in contact with the air, and has the same appearance as the vapour produced in respiration and perspiration in cold weather, or the steam from boiling water. This has been called by Bichat, *sérosité cellulaire*.—

* Bordeu, p. 31. † Bichat, p. 13. ‡ *Ibid.* p. 30.
§ Beclard, p. 136. ‖ *Ibid.* p. 138. ¶ *Ibid.* p. 139.
** *Ibid.* p. 141. †† Meckel, vol i. p. 132. ‡‡ Krause, p. 14.
§§ *Ibid.* p. 15.

The Cellular Serosity; *Zellgewebserum* of Krause.

In the living body, whilst in health, it does not ever appear to possess a distinct fluid form; but after death it condenses and becomes fluid. Haller speaks of it as "*aquula, tenera, evaporabilis, oleo aliquo mista*,"* and justly considers it as the πνευμα or spirit of Hippocrates which pervades every cavity. The father of medicine, however, does not describe it as fluid in health; his words are, "Πληροῦται τε (πᾶν κοῖλόν), ὑγιαῖνον μὲν, πνεύματος, ἀσθενῆσαν δε, ἰχῶρος,"† which plainly indicate his knowledge of the different states in which the serosity is now generally admitted to exist in health and disease. Bichat ‡ considers albumen to be a principal element of this serosity, and ascertained its presence by injecting alcohol into the cellular tissue of a dead animal, which when exposed almost immediately after exhibited numerous whitish flakes of albumen; the same appearance was also produced by plunging some cellular tissue taken from a living animal into a weak solution of nitric acid. Meckel § states that it also contains a small quantity of coagulable mucilaginous matter and some salts. It is constantly secreted by the small capillary branches of the arteries called exhalants, and is as constantly removed by the absorbent vessels. These two processes during health are in an equal state of activity, but if from any cause the equilibrium be destroyed, corresponding effects are produced; thus if the exhalant arteries are more active than the absorbent vessels, an increased quantity of vapour is produced, which, condensing in the cellular tissue, produces either œdema or anasarca, and preternaturally distends the skin; but on the contrary if the absorbents are extraordinarily excited, as they frequently are by severe diarrhœa, the moisture in the cellular tissue is removed, its bulk thereby diminished, and the skin assumes a shrivelled appearance.

Another substance is also found in the cellular tissue, about which there has been and is great difference of opinion among anatomists, as to its being contained in the cellular tissue alone, or in an independent tissue of its own, this is—

The Fat; *la Graisse cellulaire*, Bichat; *das Fett*.

This differs from the Serosity: 1. from its being solid; 2. from being contained in perfectly distinct cells; 3. from being deposited only in certain parts and not generally throughout the body; also in its composition and economy.

The fat ordinarily makes up about one-twentieth of the mass of the body;‖ it is of a yellowish colour, inodorous, and of an insipid taste. It is found in the solids in two states: 1. free as in the fat cells, or fat commonly so called; and 2. in chemical combination with other organic matter, as the nervous matter both of the brain and nerves. In the fluids also it exists, as in the chyle, blood, and milk.

In its most minute form it is granular, and the granules are so clustered together that Mascagni compares them to a mass of fish spawn. Gruetzmacher, Fontana, and Alexander Monro, who examined them with the microscope, describe them as having an oval shape. Heusinger found them round under a low magnifying power, and oval under a high one. Weber, however

* See Haller, *loc. cit.* p. 26. † See his Περὶ τεχνης, p. 17.
‡ See Bichat, vol. i. p. 50. § See Meckel, vol. i. p. 131.
‖ See Beclard, p. 159.

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states that, in fat taken from the orbit of a person who had been dead two days, he found the granules, under a very strong magnifier, perfectly round and of nearly equal size. In regard to Raspail's mode of obtaining the fat granules by a stream of water directed upon a portion of fat from a sheep, calf, or cow, placed on a hair sieve, and in which proceeding they were found on the surface of the water received in a vessel below as a snow white powder consisting of very minute crystals, Weber states that he could never produce any such powder by subjecting human fat either to a stream of water or quicksilver; and as to the angular form which induced Raspail to compare the granules to crystals, he considers that the mere weight of one soft round body upon another would account sufficiently for the assigned, and, as he conceives, its unreal form. As to the minute granules of human fat Raspail says, that when magnified to a hundred diameters they appear to be irregular hexaedral or pentaedral bodies, accurately applied to each other and incapable of isolation.

The dimensions of these granules are variously stated. Heusinger describes them as varying from 1/[illegible] to 1/[illegible] of an inch in diameter, or from 3½ to 7½ times larger than a blood globule. According to Weber, they vary from 1/[illegible] to 1/[illegible] of a Parisian inch, or ten times larger than a blood globule. Krause gives their diameter as from 1/[illegible]''' to 1/[illegible]'' of an inch. And Raspail, as from ·00117 to ·00562 of an English inch.

Mascagni has shown that each granule has its own artery and vein; that branches of blood-vessels pass into the interstices of the larger masses of fat, divide and form a network of hair-like or capillary vessels, as they are commonly called, which, insinuating itself among the smaller granules, sends an artery and vein to each, so that the granules are clustered on their vessels like a cluster of grapes on their stalk; he considered that these vessels were distributed on the exterior of each cell, and that within it was lined with a similar network of absorbent vessels; the latter was only his opinion unsupported by observation, but there can be no doubt that the fat cells are largely supplied with absorbent vessels from the rapidity with which it is frequently removed.

For a knowledge of the composition of fat we are indebted to Chevreul,* as prior to his inquiries it was held to be one of the proximate organic elements. By treating fat with boiling alcohol he ascertained it to be composed of two elements, *Stearine*,† which as the solution cooled was precipitated, mingled with a small portion of the other element, *Oleine* or *Elaine*,‡ the principal part of which remained in solution in the alcohol. Stearine has great resemblance to mutton suet; it is of a dull white colour; does not melt below a temperature of 120° Fahr.; but after fusion, as it cools it crystallizes in little needles, the mass of which terminates in a flat surface. It is principally distinguished from the stearine of mutton fat by giving out some margaric acid without any stearic acid under saponification.§ Elaine resembles oil and is almost colourless; it continues fluid at 58° Fahr., and it does not begin to assume the form of needle shaped crystals till some degrees lower 47° or 48° Fahr.‖ The small quantity of oxygen, the very large proportion of carbon, and the entire absence of nitrogen in fat in its free state in the cellular tissue, which always consists of both stearine and elaine, is very remarkable; and the following are the ultimate elements of these substances:

| | Stearine. | Elaine. |
|---|---|---|
| Oxygen | 9·454 | 9·548 |
| Hydrogen | 11·770 | 11·422 |
| Carbon | 78·776 | 79·030 |

But on the other hand, where chemically combined with other animal substances, as in the blood, in the nervous matter of the brain and nerves, and perhaps in other parts, the fat does contain nitrogen and phosphorus, and is partially crystallizable by exposure to cold. Upon the different proportions in which these two substances are contained in the fat depends its greater or less degree of firmness; thus in the hard fat about the loins the stearine predominates, and in the soft fat of the orbits the elaine.

The question as to whether the fat is contained in the cellular tissue, or whether it is contained in a proper membrane of its own, has given rise to as much dispute among anatomists as that of the cellularity of this tissue. Bergen appears to have been the first writer who made the distinction: he says,* that "the structure of the so-called cellular membrane, considered in general, admits of a twofold division; the former, where it is found between the skin and muscles, and between entire muscles consists of membranous plates expanded into spherical, oval, and rather flattened cells, connected together without symmetry and communicating here and there by various apertures; when these cells are filled with oil secreted from the blood and concreted into fat, I call the structure adipose; but when the fat is wanting, they make up the so-called cellular tissue, and therefore I call it *cellular*, or *adipose substance*. The second, as appears to me, has been observed distinctly but by very few; when the so-called cellular membrane consists of an innumerable and very intricate congeries of grains or threads, but which never form cells containing fat; these very delicate threads, arranged very obliquely, creep all over the internal substance of the viscera and muscles so intricately, that nothing certain can be said of it even with the assistance of the microscope; this then I call the *filamentous substance*." Like Haller, he thinks the then usual name of *membrane*, as applied to this tissue, improper, and employs the word *substance*, as just quoted, in reference to both his divisions of the so-called cellular membrane.

Dr. William Hunter also considered the texture in which the fat is contained to be different from the cellular tissue, and though he retained that as a generic term, he divided it into reticular and adipose membrane.† He says, "Wherever there is fat in the human body I apprehend that there is a particular organization or glandular *apparatus* superadded to the reticular membrane, consisting of vesicles or bags for lodging the animal oil, as well as vessels for its secretion; so that I would compare the marrow in the bones to the glandular and follicular parts of the fat or adipose membrane." And he grounded his opinion—1. on the granular appearance of the marrow of bones "like little bags containing oil;"

* See his *Recherches Chymiques sur les Corps gras*. Paris.
† *Στέαρ, Suet.* ‡ *Oleum*, oil. § Chevreul, p. 183.
‖ See Chevreul, *loc. cit.* p. 185.

* See his *Programma de Membrana Cellulosa*, in Haller's *Disputationes Anatomicæ*, vol. iii. p. 82.

† See his *Remarks on the Cellular Membrane, and some of its Diseases, passim*, in *Medical Observations and Enquiries*, vol. ii. p. 26.

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Zoology. 2. that in the fattest bodies there are always some parts of the cellular tissue which never contain fat; 3. that those parts which in health contain no fat, in anasarca or emphysema are filled with water or air; 4. that in the dissection of dropsical bodies there still remains a manifest difference between the adipose and cellular membrane, the former being "much more fleshy and ligamentous than the letter. To be sensible of this, cut through the skin and celluler membrane of a dropsical subject in the loins, opposite to the lumbar fascia or tendon of the latissimus dorsi, and compare the then collapsed stratum (of whet was adipose) immediately under the skin with the thick, glutinous-like substance underneath, which in the healthful state was a very thin layer of reticular membrane. This agrees with the supposition that the water and oil possess different cavities; and that in dropsical habite, the oil bags still subsist, though in an empty or collapsed state." 5. That water or blood, in the living or dead body, when lodged in the cellular membrane, gravitate to the most depending parts, "but the oil of the celluler membrane does not find those passages," and "in the fattest men we never see a drop of oil in their most depending parts." 6. That in both living and dead bodies, every fluid recedes upon pressure, air, dropsical water, or blood, the swelling pits and gradually again returns; "but the natural oil of the adipose membrane cannot be pressed from one part to another." And he then concludes, "From all these observations, may we not then reasonably conclude, that the oil of the cellular membrane is lodged in peculiar vesicles and not, as the water of an anasarca, in the reticular interstices of the part?"

This full account of Dr. Hunter's views with regard to the fat has been given because it really embraces all that has been advanced by those who hold the opinion of a distinct adipose membrane. But though emanating from authority deservedly ranking so high as Dr. Hunter, a large part of the arguments he adduces fall to the ground from the simple fact, that the *fat is in no instance in the human body in a fluid state*, and therefore cannot move about or gravitate like dropsical water or other fluids. As to the distinction between "tha collapsed stratum," or "the empty oil bags," end "the thick, glutinous-like substance underneath which in the healthful state was a very thin layer of reticular membrane," observed by him on the loins of an anasarcous subject, it only remains to be said that this is no other than a natural appearance, for the cellular tissue is always closer and more matted near the skin, in which indeed it is ultimately lost, and of greater length, more loose and therefore capable of distension by fluid as it approaches its connection with the subjacent parts. Beclard, who believes in the existence of a distinct adipose membrane, does not, however, agree with Hunter as to the endurance of the adipose cells, for he says, "When the fat does not exist, the cells also are wanting; they disappear when this fluid ceases to exist in a part. Hunter says he has seen them empty; I do not, however, believe it to be so: they are confounded when they disappear with the cellular element." This appears to be a less tenable opinion than Hunter's; for if a peculiar membrane is required to the production of fat it must, as Hunter supposed, exist always, for we cannot imagine that the adipose apparatus is destroyed every time the fat is absorbed, only that the organism may have to reproduce it when fat is again to be secreted.

The only point remaining then is as to the circumscription end independence of each vesicle or cellule or areole containing the fatty granule. Jorden, in speaking to this point, says, "The tissue of the closed adipose cells is laminar, and these are divided by much looser cellular tissue into many little cavities, from which pass still smaller compound fibres through the fatty particles." * Now the fluidity of the fat being at present entirely disallowed, it must be admitted that there is no reason why the chambers in which the fat granules are contained should be distinct from each other, but even if they be, that is no reason why the walls of the cells should be of different materials from the fibres and plates of cellular tissue. And if, as we know in innumerable instances, that the cellular serosity is secreted only at one period of life and fat only at another in the same parts, it is not unfair to presume that the arteries may be and are capable of secreting both these substances, at such time and in such parts of the cellular tissue as may be convenient with the other dispositions of the animal economy. Nor does it appear more difficult to comprehend why the fat should be deposited in certain parts only, where, if the expression may be used, it is as it were out of the way, than that the cellular tissue should be in large quantity and comparatively or entirely free from fat, where great freedom of motion is required, as in the neighbourhood of joints, where the accumulation of fat would be inconvenient.

The fat varies in quantity, disposition, and quality, both at different periods of life and in the two sexes. Beclard states† that the embryon prior to the mid period of gestation is entirely devoid of fat; but subsequently the deposition commences and takes place on the surface of the body alone and not in the interior of any of its organs. Hence originates the plump rounded form of childhood, in which it is scarcely possible to trace any bony and still less any muscular outline. At this period the fat exists in very large quantity upon the face, and it is a curious fact that though almost every other part of the surface may be deprived of its fat and the skin hang loose and flabby, it is very rare that there still remain not a very considerable quantity on the face. This external disposition of the fat continues up to and even beyond the adult period, and rarely before thirty years of age is it found to commence internally, when it is first found about the region of the kidneys and in the mesentery. As age advances, the external deposit begins to fail, the face is less plump, the features begin to sharpen, and the skin unsupported by fat falls into lines; at the same time the fulness of the lower limbs begins to diminish, and the whole cutaneous surface is disposed to laxity from the small quantity of fat laid up in the subjacent celluler tissue. But correspondent to this diminution on the surface is the increased deposition within the large cavities, and in the interior of the organs themselves. So that the fat, which had previously existed on the external surface alone, is now either alone found in the interior of the cavities and organs, or if the person be fat, in both. In consequence of this altered state, all parts of the body, both solid and soft, bones and muscles, become as it were soaked in grease, and their fibres being separated by the fat, the bones are rendered less firm and tough, and are more easily fractured, as daily experience proves; whilst even the muscles, having their compactness diminished from the same

* See Jordan, *loc. cit.* p. 420.

† *Loc. cit.* p. 166.



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cause, are less powerful. As to sex, the quantity of fat is always found proportionally larger in the female than in the male, and hence the roundness of form and less distinctness of bony and muscular outline which imparts delicacy and elegance to the female figure.

The quantity of fat varies considerably in different persons; ordinarily it forms, as already mentioned, about one-twentieth of the total weight of the body. But it may either materially exceed or fall short of this estimate without the person suffering more than inconvenience. In obesity it will form from half to four-fifths of the whole weight; and as fat is specifically lighter than water, a very stout person will not sink when immersed in that fluid; such is related of one Paolo Moccia, an Italian priest, who weighing two hundred pounds was thirty pounds lighter than a similar bulk of water, and consequently could not sink. Of course Edward Bright, of Maldon, who weighed five hundred and eighty-four pounds, and Daniel Lambert, of Leicester, whose weight was seven hundred and thirty-nine pounds, would have been far more buoyant than Peter Moccia. On the contrary, in leanness the quantity of fat diminishes and becomes extremely small; the most remarkable instance of this condition was Claude Ambroise Surat,* who was exhibited in London in the year 1825, and from his extreme emaciation, though said to be in good health, assumed the title of *Anatomie Vivante!* he weighed only seventy-eight pounds.

There are, however, some parts of the body in which fat is never found, for instance, in those parts where its presence would interfere with their functions. Thus, although in so large quantity in the orbits, it never exists in the very loose cellular tissue connecting the skin of the eyelids to their cartilages, nor in the scanty tissue uniting the skin of the auricles of the ears to the cartilages of their conch; nor in that of the scrotum, the glans-penis and clitoridis; nor in that connecting the membranes which envelope the brain and lungs to those organs. And indeed, as a general rule, it may be observed throughout the body that where motion is required, the cellular tissue connecting the organs or their parts contains little or no fat.

In some people, as for instance the Bushmen or Houazanas of Le Vaillant, there exists naturally an enormous quantity of fat upon the nates; this was the case with the female exhibited in London many years ago by the title of the Hottentot Venus, in whom the projection of the buttocks, consisting entirely of fat and cellular tissue, exceeded six inches: she died in Paris in December, 1815.†

The quality of the fat also varies according to the age; in childhood and youth it is pale yellow, almost white and very firm, giving to the surface a great degree of elasticity; but in age it becomes dark yellow and nearly of an oily consistence, hence arises the softness of the skin in old persons when fat.

*Use of the cellular tissue.*—The principal use of this tissue is that of connecting together the organs of the body and the several parts of which they consist; and hence Müller‡ has proposed for it the new and not inappropriate name of connecting tissue, *Bindegewebe.* It varies in length, or, more strictly speaking, in quantity and in openness in proportion as greater or less motion is required among the parts which it connects, as has been already stated. Sometimes it is much condensed, forming the walls of certain spaces in which particular organs are as it were isolated from those in their immediate neighbourhood, which might otherwise interfere with their functions, as in the sheaths of arteries, or for the purpose of connecting as it were into one numerous little masses of the same structure, forming a single organ, as in the capsules of glands. It also forms cushions to prevent undue compression of those parts which are naturally and of necessity exposed to pressure; instances of this purpose are presented in the soles of the feet, especially upon the heels and immediately behind the roots of the toes, upon which parts the weight of the body is received in standing, walking, &c.; upon the rump, which receives the weight of the trunk and upper limbs in sitting, in a minor degree also upon the fronts of the fingers, which in the ordinary uses of the hands are subject to much pressure. In all these cases the cushions are, if it may be so expressed, stuffed with very soft fat, collected into numerous globular masses about the size of small peas, and loosely connected by other cellular tissue in which little or no fat is contained; by this arrangement the pressure applied is very minutely divided, and is in no part so great as to interfere with the circulation of the vessels or to cause numbness of the nerves. On the fingers also these cushions serve the purpose of spreading out the skin so as to increase the surface on which the extreme branches of the nerves of touch are expanded. In the orbits also cushions of very soft fat are placed in which the eyeballs are embedded, the especial use of which appears to be to form an elastic bed counteracting the too violent actions of the muscles of the globe in those motions which are necessary for its focal adjustments.



Another very important office of the cellular tissue is that of giving origin to the absorbent vessels. It is true that it is impossible by injection to prove the existence of the absorbent radicles, but the rapidity with which solutions of different substances injected into the cellular tissue produce their effects is strongly in favour of it, as also the absorption of the natural contents of the tissue, the serosity and fat, which under severe purging are removed with a quickness almost incredible, so that a person whose skin appears almost bursting with fat or fluid, is in the course of but a few hours rendered thin and has the skin shrivelled or hanging about in loose folds.

A function of much less consequence than either of those already mentioned, but one which the cellular tissue always performs, is that of filling up the numerous interspaces arising out of the approximation of parts of very various and uncorresponding form, so that the contour of the body does not exhibit those abrupt inequalities which it would otherwise; an excellent illustration of this fact is exhibited in the packing of the windpipe, gullet, muscles, and other parts existing in the neck.

The use of the vapour with which the cavities of the cellular tissue are plentifully lubricated is to keep the tissue constantly moist and render its motions easy. The fat, as has been already mentioned, is of great service in assisting to form the cushions for relieving pressure. But it has another very important function; it forms a reserve of the superfluous nutriment received into the body, which, being stored up, is ready to supply the wants of the body, when, either from actual want of food or incapability of digestion, there is deficiency of nutriment. The fat, in these cases, is absorbed into the

* See Hone's *Everyday Book*, vol. i. p. 1017; London, 1826.
† See *Histoire Naturelle des Mammifères*, vol. i. Paris, 1824.
‡ See Muller, *loc. cit.* vol. i. p. 410.

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blood, and supplies the wants of the body so long as any of it remains; this is proved by the emaciation consequent on starvation, indigestion, fever, and other causes; and hence the person so circumstanced may be truly said to live upon himself so long as any fat remains. That this is one very important object in the storing up of fat is proved by the different appearance of those brutes which hybernate: immediately prior to their retiring to their many weeks' sleep they become extremely fat, but when they wake in the spring, they are found very lank and thin, having had no other food than their own fat to live upon during their long rest. A very remarkable instance of an animal feeding upon itself is that of a pig known to have weighed a hundred and forty pounds just previous to the falling of part of Dover cliff, in December, 1810; the animal was buried by the rubbish in its stye, without injury, for one hundred and sixty days, when it was dug out alive weighing only thirty pounds; during this long period it probably had nothing beyond the litter in which it lay at the time of the accident, a little chalk, the marks of its teeth being visible upon the cliff, and the water which had trickled through its prison.*

### Of the Nervous Tissue.

*Tela Nervea*, Lat.; *das Gewebe der Nervensubstanz*, Germ.; *le Tissu Nerveux*, Fr.

Amid the general advance of physiological science, cultivated as it has been by talented and philosophical investigators, and yielding a liberal harvest in the many valuable discoveries which have immortalized their authors, it may seem strange, yet it is no less true, that until within a comparatively recent period but little had been added, for centuries, to our knowledge of the functions of the nervous system. In seeking to account for this apparent anomaly, the difficulty of the subject, the delicacy of the requisite investigations, and, perhaps more than all, the extent of then uncultivated soil, which held out the temptation of an earlier and more ready return for labour otherwise applied, may be recognised amongst the most probable causes of its comparative neglect. Be that as it may, it is certain that anatomists were satisfied with the most vague, ill-founded, and unphilosophical explanation of the phenomena attributed to nervous influence; and substituted crude hypothesis and simple conjecture for deductions based upon the only sure foundation of observation and experiment. During the last few years attention has been fully awakened to the importance of the subject, and to our real ignorance of the greater part of the details connected with it: investigations have been conducted and phenomena watched, from which inferences have been drawn and facts established, that form a most important era in the history of physiological discovery; of this, however, anon:—suffice it at present to remark, that the reaction has brought with it (as usual in such cases) its drawback, as well as its substantial benefit. Although much has been done, a vast field still remains unexplored, and probably few subjects in the whole extent of scientific inquiry hold out more temptation to the *speculative* physiologist than that under consideration: hence the still vague conjectures, and the spirit of reclamation which has been engendered: and hence, likewise, the multiplied, useless—and cruel because useless—experiments upon living animals.* Such being the present state of this branch of physiology, it is requisite to be particular in the selection of facts, and acceptance of theories deduced from them: yet conciseness will demand a more dogmatical style, as well as a more succinct and cursory treatment of many parts of the subject, than if the prescribed limits were such as to permit its further extension.

The several points for discussion will be arranged in the following order:—A brief outline of the functions required of a nervous system will be succeeded by a sketch of the progress of this department of physiology from the earliest period. The detail will comprise,—1. Examples of various types of the nervous system; 2. Composition—chemical and microscopical—of nervous matter; 3. Structure of nerves, and their general organization; 4. *General* properties of nervous matter; 5. *Special* nervous physiology, embracing the functions of different nervous axes or centres and their appropriate nerves, viz.: *a.* Cerebral; *b.* True spinal; *c.* Sympathetic, or vegetative system. This last division will include remarks on the relative developement of the different axes, and of individual parts in each axis in man and the lower animals.

In *anatomical* language, the nervous system may be defined as consisting of a peculiar matter called *neurine*, distributed so as to form masses or centres, with cords of similar material deposited in appropriate sheaths, and communicating between these centres and most—probably all—of the organized structures of the body. If the aid of the *physiologist* be now called in to add his definition, he would reply, that the "centres" spoken of by the anatomist are so many *axes*, or *sources*, of what—for want of a better name—he terms "nervous influence;" and that, further, the *cords* are composed of different sets of fibres, usually divisible into *centripetal* and *centrifugal*, or those communicating between the before-mentioned axes and the various structures in which they terminate. To the former the generic title of "ganglion" has been assigned, whilst the latter are called "nerves." Such, then, appear to be the *essential* constituents and characteristics of a nervous system wherever it can be satisfactorily traced. The succeeding preliminary sketch may suffice to give a general idea of the functions emanating from, or controlled by, this important part of the animal frame.

Probably the simplest classification of the nervous system in its more developed form (as in the higher animals and man) is, into that division concerned in the phenomena of *animal* life, and that which presides over *organic* life: under the former head are included such motions as result from the operation or influence of the will, and common and specific sensibility; whilst the latter comprises such functions as are performed independently of the will of the individual, over which he has no direct control; such are the process of assimilation in all its details, and the production or generation of animal heat. To these phenomena (which are in some mysterious manner essentially dependent upon and connected with the nervous centres as their sources, or prime movers) must be added, to make the

* See *Annual Register*, vol. liii.

* Of the value of experiments on living animals, when scientifically conducted, there can be no doubt; and probably they are in some instances justifiable, where their direct tendency is to yield information which may be of avail in the alleviation of human suffering: it is the repetition of experiments for individual satisfaction, or without even a plausible object, that is so much to be deprecated.



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sum of the functions complete, the "mind," or reasoning and instinctive faculties; not as emanating from, but doubtless in some sort linked with, the encephalic axis, or brain. Thus, exclusive of the metaphysical division of the subject, it will be observed, that the principal functions of the nervous system may be resolved into three heads; viz., *muscular motion*, *sensation*, and *assimilation*.

*Muscular action* has been spoken of as being, in one of its forms, subservient to or excited by the will. Now it is essential to a correct understanding of a subsequent division of the subject, that a clear view should be entertained regarding the difference between the *desire* and *power* of willing an action. These passive and active faculties of the mind must operate coincidently, in order to the production of muscular motion; and such condition of the nervous centres as allows of this result is that which is usual in health: but the passive faculty may survive when the active is either suspended or totally annihilated; and thus it is seen that voluntary motion is merely the *result*, and essentially dependent on the prior operation of the will; and the capability possessed by the latter of inducing the former is an evidence of the integrity of the nervous as well as muscular structures concerned. The unfortunate victim of fractured spine and compressed cord is an instance illustrative of the preceding observations: in him an important link in the chain of communication between the seat of the will and those muscles placed below the seat of fracture is severed, and thus, though possessing the *desire* to rise, he lies prostrate and helpless. The bearing of these simple remarks will become apparent as we proceed. A second form of muscular motion is that which is purely independent of any direct control of the will; of this class the heart is an example: and the third head includes such motions as are of a mixed character, *i. e.* usually involuntary, but subject, under particular circumstances, to the influence of volition; such are the muscular acts concerned in respiration. Each of these forms of muscular motion is referable to appropriate nervous axes, or centres.*

The next general head of which mention will be made is *Sensation*. If literally defined, this expression signifies "perception through the medium of the senses; a consciousness of some physical influence; an impression made on the nerves, and by them conveyed to the sensorium, or seat of consciousness and sensation." Under this head are included *common sensation*, with its modification, the sense of *touch*, by which we are enabled to distinguish between hot, cold, rough, smooth, &c.; also the *other four senses*; and likewise the pleasurable and painful sensations of which the sensorium is rendered cognizant, and which may be regarded merely as deviations in excess. It is necessary to guard against the error of identifying with sensation a somewhat analogous property resident in the organs of contraction and assimilation; viz., the capability of being excited to the performance of a function by an appropriate stimulus: this also implies an impression; but of a character which may be totally independent of the sensorium, or seat of consciousness; and to which the distinguishing title of "appropriate excitability," or (to use a more familiar one) "irritability," may be assigned.

* For a further exposition of this subject, the reader is referred to Muscular Tissue, p. 170.

Lastly, with regard to the process of *Assimilation*. By this term is meant the results of vascular action; including, besides the mere conversion of the food into blood, the processes of deposition, absorption, secretion, and exhalation. The existence of each of these properties is more or less evidenced by all living organized matter; and, collectively, they form the functions of organic life in animal matter. The ganglionic or vegetative system of nerves presides over these actions, and is, consequently, the ultimate directing and balancing agent in nutrition, growth, and decay. The subject of the generation of animal heat has occupied the attention of many physiologists, amongst whom the names of Crawford and Brodie deserve particular mention: from the combined results of their experiments it is reasonable to infer, that animal temperature is in part due to nervous influence, and in part the product of chemical action.

From the preceding cursory review of the functions of the nervous system, some idea may be formed of its importance in the production and superintendence of the various phenomena which characterize living organized matter. To say that the nervous system is the exclusive seat of vitality is erroneous: all organs aid, in their several degrees, by their *structure*, in the constitution of the *body*; and by the exercise of their appropriate *functions* in the developement of that *living principle* by which the body is endowed. Thus, the nervous centres, the circulating system, the organs of sensation, motion, and assimilation, each form a part of this wonderful chain, the injury of a single link of which suffices, perhaps irremediably, to impair, or even to annihilate the vitality of the whole.

It may be well here to make a passing comment on the questionable existence of a nervous system in *Vegetables*. Those who have entertained the affirmative, have based their opinions upon the inferred necessity of analogy of structure where there is apparent identity of function, rather than upon anatomical or experimental grounds. It is true that the assimilating process in plants is to a considerable extent analogous to that in animals; and further, that they possess the characteristic property of excitability in the performance of this and other functions: yet the existence of this analogy is not by itself sufficient to justify any inference regarding the presence of a nervous system in plants, although the interesting nature of the inquiry, and the plausibility it derives from the coincidence noticed, may be a sufficient excuse for entertaining speculative opinions upon the subject. It would be irrelevant to discuss this question in detail, the present article being destined to the exclusive consideration of the nervous system as it is known to exist in the animal kingdom.*

To return. One of the most prominent features which characterises *animal* life is the capability of communicating with surrounding nature; and in proportion to the developement of *general* organization and the needs of an animal requiring locomotive organs, is found a corresponding *special* developement of the organs of sense. Now, in speaking of these, the "organs of sense," by which we hold commune with the world around us, we are apt to refer the experience which we acquire (as for instance in the eye and ear) to the modifying apparatus rather than to the real source,—

* The reader may consult the works of Treviranus, De Candolle, Raspail, Lindley, Henslow, and others on Vegetable Physiology. Also the succeeding article on "Muscular Motion."

Zoology. the nervous supply. This fallacy, which is only the offspring of thoughtlessness, should be corrected, as it certainly complicates the subject, and interferes with a ready comprehension of the analogies which exist between the simplest and most highly endowed organized structures. Thus, the beautiful microscopic and telescopic apparatus presented by the various humours and lenses of the eye serve but the subsidiary office of modifying the rays of light, as they are admitted to impinge upon the sensitive surface, the retina. So likewise the complex labyrinth which constitutes the internal ear has but to conduct, to modulate, to qualify abrupt impressions, and to present a surface for the extension of the auditory nerve. Thus, whatever may be the mechanism by which external impressions are modified, or rendered *special*, all are referable to one common source, viz., the nervous system. It is by an easy transition that we pass to the conclusion to be deduced from this simple statement;—which is, that the less complex the modifying apparatus—or, in other words, the simpler the senses and fewer the wants of the individual—the more simple and more generally diffused we should expect that division of the nervous masses to be, which superintends the organs through which external impressions are received. As will be remarked a little further on, man does not hold the first position in this respect. Again, in reviewing the organs of assimilation or of locomotion, it is equally palpable that complexity of function and perfection of organization go hand in hand. Nor does this relation hold good in connection with physical developement alone. Intellectual superiority, and a corresponding expansion of that division of the nervous system with which it has pleased the Creator mysteriously to connect the mind, exists beyond dispute; and in this characteristic man assumes his lofty station far apart from the creatures which are placed beneath his sway.

The apparent universality of most of the animal functions alluded to would seem naturally to imply an equally universal existence of a nervous system. This, indeed, appears to be the case; for, evidence of such existence has been detected in every division, and in nearly every class of the animal kingdom: and the fact of nerves having in some instances eluded observation, is not to be received as a conclusive evidence of their non-existence. It is a source of natural wonder with which it is difficult to become familiarized, that organized beings, which our unaided sight is incapable of detecting, should live and move and be possessed of appetites, and in fact be influenced by the various motive causes which operate in directing and controlling the functions of our own organs. Yet, that such is the case, the examination of a drop of water will sufficiently testify. Our notions of magnitude are merely *relative:* and the consideration that, as an absolute or abstract quality, magnitude is nothing in His hand to whom all things are equally easy, should allay our wonder and act as an antidote to a ready scepticism in our generalization upon subjects, where analogy is our principal guide. Now, according to the observation of those physiologists who have given their attention to the investigation, (Ehrenberg and Grant more especially,) some of the simplest forms of polygastric animalcules appear distinctly sensitive to light: and, as Grant remarks, "the organs of vision, in the form of minute red points, are seen in almost every genus." Further, "they appear also to possess an acute sense of taste, they distinguish, pursue, and seize their prey, they avoid impinging on each other while swimming, crowded in myriads, in a drop of water; they contract and bend their bodies in every direction, and they increase or retard, or cease at pleasure, their progressive motion and the vibration of their cilia, like the muscular and gangliated rotiferous animalcules; yet nervous filaments have not been distinctly detected in the minute transparent bodies of the polygastrica. The numerous straight parallel jaws, seen in many of the genera, are opened and closed, advanced and retracted, with great quickness and precision, and all the movements of these minute animals appear to be as regular, methodical, spontaneous, and well directed as those of many higher animals with obvious nerves." * Such is the account given by Dr. Grant, whose work is quoted as more readily accessible to the English reader. Those who desire to consult the original observations on this subject will find them in a paper by Professor Ehrenberg, in the *Transactions of the Academy of Sciences of Berlin*, for 1831, p. 14; where this indefatigable observer further remarks, that from their well-directed motions and analogous developement of structure, he infers the existence of eyes even where the red points above alluded to are not found. Zoology.

One important end which determines the mode of distribution of the nervous system is *convenience*, or adaptation to the general organization and properties of an animal: thus, as already remarked, in some the nervous centres are found scattered or diffused throughout the whole frame, whilst in others they are concentrated. In the poriphera we have the most striking example of the former character of nervous system. These animals "possess the same living properties in every part, and are almost indefinitely divisible without loss of vitality." There can be no question, adds Dr. Grant, that in this group of the Radiata, (the lowest in the animal kingdom,) the "component particles of the nervous and muscular systems are diffused through every part of the soft cellular tissue of the body." †

*Types of the Nervous System.*

The most important distinction which presents itself in the forms of the nervous system is, as already noticed, between that of the vertebrate, and that of the invertebrate series. These names explain themselves; but it is necessary to remark that, in the latter, where the brain is comparatively unprotected, the representative of that organ is a nervous ring or collar through which the œsophagus passes; and that the remainder of the nervous centres (if any) consist of an abdominal cord or cords presenting a series of ganglia, and modified according to the form and general organization of the animal. Until recent discoveries in both comparative anatomy and physiology set the matter at rest, many authors confused these ganglia of invertebrate with the ganglia of organic life in vertebrate animals. This supposed analogy has recently been proved fallacious, as each system in the one class has been shown to possess its analogue in the other.

*Invertebrate Series.*—In illustrating the various types of the nervous system in these animals, their arrangement by Cuvier under the three great divisions of Radiated, Articulated, and Molluscous animals, is that

* *Outlines of Comparative Anatomy*, p. 181.
† Grant's *Outlines, &c.* p. 182.

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most generally employed, each of which will require observation.

In Radiated animals, of which the star-fish is an instance, the nervous system is found in its simplest and most primitive form; the central organ being a ring of nervous matter surrounding the œsophagus, or rather orifice of the stomach, and giving off, opposite each ray, branches for its supply: this ring presents no ganglionic enlargement, and, as the characteristic of this class of animals is "the arrangement of similar members round one centre," no cord-like prolongation.

The distinguishing type of Articulated animals is that of a body consisting of a repetition of parts which are similar or identical in structure and function. Thus, in the annelida, or red-blooded worms, the body is formed of a succession of rings, each of which contains similar parts of the vascular system and viscera. Again, in insects, in the arachnidan and crustaceous animals, the same arrangement holds good; but these differ from the annelida, by being "possessed of articulated limbs terminated by claws: and in connection with the superior powers of locomotion afforded by these appendages the sexes are separate, and the organs of vision are well developed and often highly complicated."* In correspondence with this extended general organization, a gangliated nervous cord is developed, each ganglion supplying its appropriate segment; hence the capability which the fragments of such body, when divided, possess, of retaining their vitality independently of each other: in the perfect animal, the œsophageal ring may still be recognised as the analogue of the brain in the vertebrata, although in function it certainly is not exclusively so. With respect to the agreement between the number of segments of the body, and the ganglions of the nervous system, Mr. Owen remarks, that "in the higher crustaceans, arachnidans, and insects, the ganglions, though originally as numerous as the segments, subsequently become concentrated by progressive developement into masses which are fewer in number, and that also in some of the lowest annelidans, as the leech-tribe, the external segments are more numerous than the internal ganglions."† It may be added, "that the *homogangliate* disposition of the nervous system essentially distinguishes the *articulata* from the *molluscous* and other divisions of the animal kingdom; the uniting ganglions in the former being confined to the mesial line of the body, perfectly symmetrical in their arrangement, and accompanied by a symmetrical or bilateral form of the whole body."‡

In the Molluscs, as for instance the fresh-water muscles, there is no division of the animal into members, and the articulate structure is absent: the symmetry of the other two classes is wanting, a muscular sac surrounds the viscera, and the muscular apparatus is adapted to the sluggish locomotive powers of the animal. To these characteristics there is a correspondent change in the nervous developement: the primitive œsophageal ring is still present, to which are superadded ganglions, which are found both on the ring and on the branches therefrom derived.

Thus, from the preceding cursory review of the general characteristics, and varied form and developement of the nervous system of the three lower divisions of the animal kingdom, proof has been obtained of the remark with which these observations were introduced; viz., that the peculiarities which distinguish each division, as indeed each class, are dependent on and modified by varieties of form in the general organization of the animal, and therefore adapted to its habits, its external configuration, the developement of the senses, the position of viscera, and its powers of locomotion. It has been farther remarked, that there is no reason to infer that the nervous ganglia of this division are correspondent to the sympathetic nerves of the vertebrata. There are ganglia connected with the origin of the cerebro-spinal nerves in the latter, as well as with the nerves of organic life; and further, even in mammalia, the spinal cord presents enlargements at intervals corresponding to the origin of large nerves: we may therefore be justified in the conclusion, that analogous structures receive their supply of nervous influence from analogous sources; or, in other words, that the innervation of the *viscera* on the one hand, and of the organs of *sensation* and *motion* on the other, emanates, in the invertebrate classes, from appropriate axes or centres which are analogous to the cerebro-spinal and organic systems of nerves in the vertebrate subregnum.

*Vertebrate Series.*—The characteristic of a vertebrate animal is, as the name implies, the possession of a bony column, the object of which is to form a protecting covering to a part of the nervous centres: and this is combined with a capability of performing varied and extensive acts of locomotion; so that in this class also may be recognised a further evolution of the same principle which determines the form and distribution of the nervous system in the lower animals; viz., adaptation to general structure and function. This guiding principle is further evidenced by the accumulation of a large portion of the nervous centre at the upper part of the column, near to the seat of the senses, where these organs assume a more decided developement, and have a more important part to play in connection with the well being of the individual. Such then is the general type of the nervous system in the vertebrata, viz., the possession of a brain and spinal cord, severally enclosed in a skull and vertebral column.

### *Structure of Nerves.*

*Anatomical and Microscopical Characters.*—The *structure* of nervous substance is a branch of general anatomy which has been recently cultivated with much success by our German contemporaries: the names of Ehrenberg, Treviranus, Burdach, Müller, Remak, and Valentin deserve particular mention, and their labours will be more particularly adverted to in the sketch of this division of the subject.*

In unravelling or dissecting a *nerve* it is found to consist of large fasciculi contained in a neurilemma; and these are reducible to smaller fascicles, which in

* Owen, in *Cycl. of Anat. and Physiol.* vol. i. p. 245.
† *Ibid.*
‡ *Ibid.*

* The titles of their works are here given to save repetition of reference.

*Beobachtung einer auffallenden bisher unerkannten Structur des Seelenorgans bei Menschen und Thieren.* Von C. G. Ehrenberg. Berlin, 1836.

*Beiträge zur Aufklärung der Erscheinungen und Gesetze des organischen Lebens.* Von G. R. Treviranus. Bremen, 1835-7.

*Vorläufige Mittheilung über den innern Bander Cerebrospinalnerven, &c.* Von R. Remak. In Müller's *Archiv.* Jahrgang. 1836.

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Zoology. turn are composed of primitive fibres. The fascicles interchange fibrils, but the primitive fibres never unite. When carefully examined under the microscope, these primitive fibres are found to be—not globular, as was formerly supposed, but simple threads, the diameter of which is very variable, raoging, accordingto Ehrenberg, from $\frac{1}{48}$ to $\frac{1}{1000}$ of a line in the invertebrata, but presenting an average of about $\frac{1}{150}$ of a line in the vertebrata. This accurate observer describes all the nerves which he has examined in the vertebrata, with the exception of the olfactory, optic, auditory, and part of the sympathetic or organic nerves, as constituted of minute cylindrical tubes, lying parallel to each other, of the size above indicated, and never anastomosing.* Thus the essential structure of a nerve is identical with that of the nervous centres, with the addition of a cellular sheath (the *neurilemma* which forms the investment of the *whole* nerve and *each* bundle) divided into compartments or tubules, in which the soft medulla is deposited. The object of this arrangement is to give firmness and consistence to the pulpy nervous mass, as well as to preserve the individuality of each ultimate fibre throughout its course: the absence of the former necessity accounts for the non-existence of the neurilemma in the nerves above enumerated. If the fibrils of a nerve are examined under a high magnifying power, they are found to preseut an undulated appearance, which Burdach attributes to the relative shortness of the investing tubule as compared with the contained nervous matter; a wise arrangement, as he remarks, to prevent injury during the varied movements of the body and limbs, when the nerves are put on the stretch. The desire to distinguish, by the discovery of some structural peculiarity, the motor from the sentient fibrils induced Ehrenberg, Remak and others to subject these several roots of the spinal nerves to careful observations; the results, however, were not of a conclusive nature, although the former physiologist at one time believed that varicosity constituted a distinguishing characteristic of the sentient fibril, and the latter, that the motor fibril may be detected by its greater thickness. The ultimate fibres of the grey or orgaoic nerves are found to be more minute, and homogeneous in structure, (*i. e.* without tubules as in the spinal nerves;) they are likewise paler and translucent, but the most unequivocal characteristic consists in small round or oval bodies which are observed here and there on the surface of the organic fibres. In consequence of the interchange of fibrils between the two systems, ultimate organic fibres are to be met with in the cerebro-spinal nerves, and the converse is likewise the case. These observations were first made by Remak, who has also confirmed the account previously given by Fontana, of the primitive white fibres. The same physiologist also gave a description of the primitive fibres of the brain; but Ehrenberg has more recently published an account of his own observations.† He describes them as presenting a tubular structure with dilatations at intervals, thus giving the impression of "jointed tubes," and thence named by him "varicose:" he therefore rejects as erroneous the earlier hypothesis of the simply fibrous or globular structure of the brain. He further adds, that these canals are generally continuous, *i. e.* rarely dividing or anastomosing, but running in straight lines, and increasing in thickness as they converge towards the centre of the cerebral mass. These observations have been in a great measure confirmed by more recent investigators. Treviranus, Valentin, and others deny the varicosity of the tubes, even under pressure, whilst the brain continues perfectly fresh; but, admitting the *tendency* to this appearance in the primitive canals of this division of the nervous centres, as well as in the spinal cord, and olfactory, optic, and auditory nerves, they ascribe it to the changes of decomposition, and assert that an uniformly cylindrical character is the normal condition; an opinion in which Müller appears to coincide. Zoology.

The ultimate structure of *ganglia* has been investigated principally by Valentin, who describes them (as they exist in the higher animals) as composed of spheroidal globules, possessed of a central nucleus: the fibres which enter the ganglion arrange themselves in a plexiform manner around these globules, subsequent to which they again emerge to join the trunk whence they were derived. The same anatomist further remarks that the grey substance of the brain and spinal cord is composed of globules identical with those of the ganglia above described, differing only in having a less firm cellular investment. It may be added that, according to Müller, upon the qnaotity of these grey globules depends in great measure the relative intensity as regards colour in the brain; those parts which deviate more from the white medullary character presenting more globules; but the deepest colour be ascribes to a pigment deposited on the globules.

Thus, then, it will be observed that the cerebro-spinal and organic *nerves* differ, as regards their primitive constitution, only in the relative amount of their constituent materials; the former containing but few grey or organic fibres, and the latter but few of those belonging to animal life: whilst the medullary or white, and cineritious or grey material of the various *centres* presents an essentially different primitive structnre.

*Chemical Characters.*—Vauqnelin gives the following analysis of the brain:—

| | | |
|---|---|---|
| Albumen | | 7·00 |
| Adipose matter | Stearine 4·53; Elaine 0·70 | 5·23 |
| Phosphorus | | 1·50 |
| Osmazome | | 1·12 |
| Acids, salts, and sulphur | | 5·15 |
| Water | | 80·00 |
| | | 100 |

It should be remarked however, that Vauquelin's results do not agree *in toto* with those of Berzelius and some other chemists: but for further information the reader may consult the first volume (or that on Structural Anatomy) of Weber's edition of Hilderbrandt's *Anatomy*, p. 257, 1830.

*Course of Nerves.*—Sufficient insight has now been obtained into the general functions of the nervous system to oppreciate the very great importance which must be attached to the inquiry, which involves the question of the separate and independent course of

*Beiträge zur Mikroskopischen Anatomie der Nerven.* Von E. Burdach. Königsberg, 1837.

*Handbuch der Physiologie des Menschen.* Von J. Müller. Berlin, 1835.

*Ueber den Verlauf und die letzten Enden der Nerven.* Von G. Valentin. In *Nova Acta Cur. Nat.* vol. xviii. Breslau und Bonn, 1836.

* *Op. cit.* p. 24.

† *Ibid.* p. 20.

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the primitive fibres from their relative centres to their extremities; for, although an anatomical fact is not alone sufficient to direct or determine a physiological inference, yet, had examination proved that the nervous matter actually intermingled in the course of the nerves, it would have very much puzzled anatomists to account for the accuracy with which sensations are localized, and muscular movements produced at will. Fortunately, however, the *à priori* deduction coincides in this instance with the hypothesis on which it was founded, or rather which was grounded on it; and the shrewd conjecture of Whytt, who saw how much depended on the clear establishment of this principle, has been confirmed by the microscopical investigations of Fontana, Prevost, Dumas, and more recently of Müller, who distinctly states that, to whatever extent the fascicles may unite or become exchanged, the primitive fibres still remain perfectly distinct; in short, that he has never seen the amalgamation or true inosculation of any two primitive fibres of a nerve.* Thus we learn the interesting fact that the ultimate extremity of one of these fibres, which receives the impression of the point of a needle at any part of the surface of the body, pursues an uninterrupted, an independent course, until it terminates in the sensorium, executing its commission distinctly and without confusion, a result which could not but be marred were any interchange allowed of; indeed, the capability of identifying impressions must cease; they would become as various, as confused, and as heterogeneous as the anastomoses themselves. The fact above noticed is further confirmed by the uniform size of anastomosing fasciculi, and the branches entering and emerging from a plexus, as well as the progressive and regular decrease in the size of nerves, bearing an exact ratio to the number of fascicles separated in the course of their distribution. It is scarcely necessary to add, that the application of this principle to the compound nerves of motion and sensation is equally just and most essential.

*Termination of Nerves.*—This subject has been elucidated by the observations of several anatomists, although its physiological import is far inferior to that which has just been considered. Doubtless the peculiar mode of termination of nerves destined for various purposes is of importance as connected with their peculiar function, yet the present state of our information does not allow of our comprehending the objects that are accomplished by the varieties in question. Prevost and Dumas first remarked, that the ultimate ramification of nerves in muscles terminated by anastomosing in the form of *loops*; and their observations have been subsequently confirmed by Valentin, who, with Breschet, has described the same arrangement of the ultimate fibrils of the nerves of sensation. The simple *reticulated* form of termination has been observed in the mesentery of the frog by Schwann of Berlin; whilst the isolated or *unconnected* form of termination has been described by Treviranus and Gottsche as proper to the auditory, optic, and olfactory nerves in their relative distribution to the labyrinth of the ear, in the retina, and to the nose. Ehrenberg further describes a *varicose* and *tubular* structure in the retina as well as *papillæ*, which have likewise been noticed by Weber and Treviranus; Gottsche has also remarked a *club-shaped* termination to the ultimate fibrils of the auditory nerve in the cochlea of some animals, and Ehrenberg a similar appearance in the olfactory membrane.*

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*Historical Sketch.*

A short account of the progress and discoveries in nervous physiology will form a fitting introduction to the consideration of the general properties of nervous matter. The earliest notion, and one long prevalent, was both simple and comprehensive in its application to the purpose of explaining the diversified phenomena resulting from the agency of the nervous system. Its promulgators sought to cut the Gordian knot by the aid of analogical reasoning; they conceived that the brain was a gland in which "animal spirits were elaborated," and thence conveyed along the nerves to various parts of the system, for the purpose of supplying nervous energy to different structures, and endowing them with their appropriate functions. In the primitive simplicity of this *general* knowledge upon the subject, a recognition of the relation which a nervous system holds to the rest of the frame is detected; but what its precise functions were, or how they were exercised, was unknown: far less did the ancients attempt to assign any appropriate locality to these various functions. It would seem, however, that the connection of the nervous system with sensation and motion was the first step towards individualising. The discoverer of this—to us simple and self-evident fact, is not known: but the earliest writers (Erasistratus and Aretæus) seem to have been aware of this connection. The acuteness of the great father of medicine, Galen, penetrated more deeply; for he distinctly announced his belief in the *structural* as well as *functional* independence of the nerves of motion and sensation. This appears to have been the limit of neurological discovery; for, amid the splendid discoveries of the functions of the lacteal and lymphatic systems, and of the double circulation of the blood, the nervous system still remained shrouded in darkness. The next era in the history of neurological discovery involves, as might be anticipated, a series of speculative opinions put forth by men great in their day, and of original minds, such as Vesalius, Fallopius, Vieussens, Boerhaave, and Willis; and it is deeply interesting to mark, amidst the many errors and occasionally correct views promulgated by them, how nearly great truths were sometimes approached, and again lost sight of. The special functions of some organs (such as of the senses) were, by these anatomists, assigned to their appropriate nerves; but so conjectural was even this advance, that we find the great Haller denying the existence of any nerve which did not possess the double function of sensation and motion. Next follow the writings of Whytt† and Prochaska‡, whose observations on "reflex or spontaneous" movements curiously bear upon the most recent discoveries in our own days. Dr. Whytt's remarks in the papers alluded to have

* Müller, *Handbuch*, 1834, p. 586 and 659.

* The reader may consult with advantage for further details the excellent articles *Eye*, and *Hearing, Organ of*, by Jacob and W. Jones, in the *Cyclopædia of Anatomy and Physiology*, vol. i. at p. 185 and 541.

† *Essay on the Vital and Involuntary Motions of Animals*, particularly sections 10 and 11. Also subsequent papers on *Sensibility and Irritability*, and on the *Sympathy of the Nerves*. *Collected Works*, 1768.

‡ *Commentatio de Functionibus Systematis nervosi. Opera minora*, 1800. Vol. ii. cap. 3. *Functiones Nervorum*. Cap. 4. *Functiones Sensorii communis*.

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Zoology. reference principally to the independence of the spinal marrow as a centre of nervous influence—a point which he amply illustrates by experiments on decollated animals: his conclusions were strictly in accordance with those of more recent discoverers, with the single but not unimportant exception, that he defended the hypothesis that *sensibility* was necessary to the production of reflex movements; although he admits that it (sensibility) "will not be attended with what is called consciousness, as distinguished from common sensation, because this is a faculty exercised by the brain only," &c. It appears strange that, when so near the truth, this acute physiologist should have preferred the dilemma of supporting his theory by a paradox, such as the above quotation certainly is, unless a different or more inclusive meaning is attached to the word "sensibility" than that which its usual acceptation admits of.* Prochaska was both more definite and more accurate in his speculations. In the *Commentary* to which reference is made, he proposes to himself the question of the "seat and functions of the *sensorium commune*." Like Whytt, he speaks of reflex movements of which the mind is unconscious,† though he refers them to his sensorium commune, which he conceives to be regulated by appropriate "physical laws," admitting of "automatic and spontaneous actions." The most "general law" referred to is that of self-preservation, which induces involuntary motive impulses under the stimulus of appropriate impressions, which are "propagated along the sensorial nerves to their origin, where, passing into corresponding motor nerves, they are reflected to the muscles."‡ Lastly, in speaking of the limits of the sensorium commune, he describes it as the "centre in which the nerves, both of sensation and motion, meet and communicate, and in which impressions are reflected, . . . *i. e.* extending as widely as the origin of the nerves themselves." About this period the roots of the spinal and fifth nerves became the subject of investigation; and, as the result, we are indebted to the first Monro for the anatomy of the ganglia on the posterior roots of the spinal nerves; whilst Wrisburg observed the two roots of the fifth, and Sœmmering and Prochaska pointed out the independence of the anterior root in relation to the ganglion; yet neither of these anatomists, nor their great contemporary Scarpa, seems to have had any idea of their real independence of function. The dissections of Paletta, indeed, showed him that the anterior root of the fifth was exclusively distributed to muscles, and hence he inferred that it was purely a nerve of motion; but here his conjecture ceased.

No notice has yet been taken of the so-called sympathetic nerves. The truth is, that until the time of Winslow, this system appears to have been considered as an appendage of the cerebro-spinal axis, which fact, together with the more correct views entertained by this anatomist himself, may be collected from his writings. It was left for the acute Bichat to point out more distinctly the *functional* independence of the sympathetic ganglia and nerves; they were by him styled the "system of organic life:" and although, as we have seen, this system was already before his time recognised as separate from the cerebro-spinal, and although his theory in relation to its real functions was founded on the supposed analogy between it and the central chain of ganglia in the articulated classes (the fallacy of which has been already pointed out), yet we must not withhold the merit that Bichat may justly claim, for having directed attention more especially to the functions of the central ganglia in connection with the processes of assimilation, or, as the sum of these functions is sometimes termed, organic life. Bichat was, however, wrong in excluding the cerebro-spinal system from any participation in the control of the vital functions. The probable analogy which exists between the ganglia of the sympathetic and the cerebro-spinal axes, in the *reflex* influence they exercise over the motions of the heart and other viscera, is a suggestion of more recent date. In our review of the past, we must not forget the acknowledgments due to Gall for his researches into the structure and mode of exhibiting the fibres of the brain; points for which the general physiologist, at the least, is more indebted to him than for his craniological chart; though it were a great mistake to suppose that this improved method of dissection was original, at any rate, in conception with him. As early as the year 1668, we find the anatomist Steno (in his "Dissertation on the Brain") inveighing against the method of dissecting this organ from above downwards, and predicting that, only by a new mode of dissection in the course of its fibres, could any advancement in the discovery of its real structure be hoped for. Zoology.

Neurological physiology was thus advancing, though but slowly; and the last few years have been more prolific in discovery than the whole preceding period through which its course has been traced. To our own contemporaries it is that we are principally indebted; and whatever may still be our ignorance respecting the nature of what is vaguely termed "nervous influence," we can no longer complain with Winslow, Haller, and other anatomists of their time, that we continue in darkness regarding the leading properties of the nervous axes, and the appropriate media through which they act. The oft-discussed question of priority of claim between Bell, Magendie, and Mayo, will be avoided as unprofitable and therefore irrelevant:* a brief account of the experiments and discoveries of Sir C. Bell will suffice to form a fitting introduction to the more extended system since developed by Dr. M. Hall and Professor Müller—a subject which will presently demand consideration.†

Sir C. Bell's first notions upon this subject appear to have partaken of the vagueness common to the discovery of great principles which are viewed but dimly in the distance, and shrouded by the garb of previous and perhaps long-established error. He recognised, as had been already done, the principle of varied function attributable to the nerves, and then conceived the idea which involved the doctrine of the "plurality of endowments in different nervous trunks, and in different parts of the same trunk." "The first conception," observes

* It is but fair to give this acute and learned writer's own explanation. He considers that the mind may act as a *sentient*, though not as a *rational* principle, in producing involuntary movements; and that it may be unconscious of impressions. *Collected Works*, p. 152.

† *Op. et loc. cit. Ista reflexio vel anima inscia, vel vero anima conscia fiat.*

‡ Ibid. The opinions of these authors have been *particularly* quoted, on account of recent discussions in which they have unconsciously held a prominent position.

* Those who desire to become acquainted with the merits of this question will do well to consult a small work recently published by Mr. Shaw on the subject; also *Documents and Dates relative to the Nervous System*, by A. Walker, 1839.

† Under the head of *Special Physiology of the Brain.*





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Sir Charles, "which I entertained of the true arrangement of the nerves, arose from a comparison of the nerves which take their origin from the brain, with those which arise from the spinal marrow. The perfect regularity of the latter, contrasted with the very great irregularity of the former, naturally led to an inquiry into the cause of this difference."* Experiments were accordingly performed first upon the spinal cord, and he found that injury done to the anterior part of the spinal marrow convulsed the animal more certainly than similar læsion of the posterior columns; but much difficulty was experienced in injuring either portion without disturbing the other. Encouraged by this partial success, and being strongly impressed with the idea that some functional distinction must exist, corresponding with the anatomical difference in the origin of the nervous roots, he performed his first experiments on rabbits, by laying open the vertebral canal (the animal having been previously stunned), and "on irritating the posterior roots, no motion could be perceived in any part of the muscular frame; but, on irritating the anterior roots of the nerve, at each touch of the forceps there was a corresponding motion of the muscles to which the nerve was distributed." Sir Charles then proceeded to mark what single-rooted nerves arose from the anterior columns; and finding that they were those to which motive power was exclusively attributed (viz., the third, sixth, and ninth cerebral), this further corroboration of his conjecture led him to generalise, with more confidence, in establishing his theory of the independence of the medullary columns and their several functions. Still a difficulty remained; that of disproving a long prevailing opinion, that ganglia were intended to cut off sensation. Hence arose the experiment which this anatomist performed on the fifth and seventh nerves, which were selected as types of the anterior and posterior roots of the compound nerves; and the result was the establishment of the doctrine he had already promulgated; and the foundation was also laid for his further discoveries connected with the respiratory system. But here the subject of *special* physiology must be quitted, until the *general* properties of nervous matter have been discussed.

### *General Physiology of the Nervous System.*

Although it would be incorrect to say that Life is peculiarly localized in the nervous system, yet it will scarcely admit of much dispute, that it is through the medium and agency of this system that vital phenomena generally are importantly controlled and influenced, where they are not actually and directly dependent on nervous energy for their birth and persistent integrity. There are, however, some properties which are peculiar to, and wholly dependent on, nervous influence; such, *e. g.*, is "sensation." No one doubts for a moment that, without nerves, we could not feel; yet, albeit widely diffused, it should be remembered that "sensation" may be correctly styled a *property* of the organs therewith endowed, conferred doubtless by the supply which they receive from one of the great nervous centres. A consideration of this simple truth, combined with the necessity of, after all, referring the phenomenon to its proper seat "the sensorium," will aid in developing the principles which guide and limit the operation of the nervous system; and in assigning, when we pass on to the detail, to each division its peculiar functions. A more questionable property of nervous matter is, the control of secretion. We cannot so readily conceive that this function is essentially dependent on nervous influence, because we are more apt to regard it as a peculiar property of the secreting organ; yet it would appear rational to believe, as incorrectly so as if we considered *sensation* purely the property of "feeling organs." In the latter instance, as in the former, a free circulation is essential to the perfection of the function or property; and though referable to different sources, there can be little doubt that each is more or less directly dependent on nervous influence. The preceding remarks (which are merely designed as illustrative) are intended to exemplify that all-pervading property of living organised matter, which is so largely developed in the nervous system, viz., "*excitability*," a property which we are disposed to regard as a demonstration of the vital principle in an organ, evinced and called into action by the susceptibility or impressibility of its nervous supply. But the further discussion of this general question must be deferred until the functions of the organic system come under notice. It is therefore dismissed for the present with this single remark, that the above hypothesis is founded on the assumption of the *universal* distribution of nervous axes or sources, wherever a vital action demonstrates itself which cannot be explained by the operation of chemical or mechanical agents.

A natural inquiry here presents itself, What is *nervous influence?* It need scarcely be remarked that the expression is one of extreme vagueness, and the only means of defining it is by an illustration:—thus, in muscular motion we may observe the operation of nervous energy in a direct and indirect manner; it is called at once into action by the influence of the *will*, and is the more indirect agent where muscular contraction results from an impression made on the peripheral extremities of the nerves; this latter is termed *reflex motion*: the difference between the two cases is simply this; that in the former a voluntary agent, of which we are conscious and name *volition*, is in operation; whilst in the latter some quality or property of nervous matter, of the nature of which we know *nothing*, and with the results of which we are alone familiar, is called into action: this property, then, it is that we denominate *nervous influence*. To attempt any more definite explanation of this subject would be vain in the present state of our knowledge; nay, we might almost venture to assert that it would be more consistent with true philosophy to recognise in its peculiar attributes a primary endowment of nervous matter, rendering it the medium by which moral influence and physical impressions are propagated or communicated to various parts of the system: in short, that as the astronomer, who stoops not to the pitiable resource of investing *inanimate* nature with innate or self-endowed properties, at once recognises in the *vis inertiæ* of matter the direct agency of the Creative Hand, so the physiologist may reasonably admit that *nervous energy*, in its varied manifestation, is itself a first law—a direct endowment; whilst he seeks to investigate, as a legitimate field of inquiry, the conditions under which this mysterious agent is called into

* Bell's original paper (printed but not published in 1811) has been reprinted in the *Documents and Dates* to which reference has been already made. His second paper was read before the Royal Society in 1821. The paragraphs between inverted commas are from his *Anatomy of the Nervous System.*

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operation; and to unravel, as far as may be, the complex questions involving the extent of its influence in originating or controlling the various phenomena evinced by the living organism. Thus the proper object of present inquiry is the laws which regulate the operation of the nervous system; or, in other words, the conditions under which nervous matter may be impressed, so as to render active its peculiar attributes; for it should be remembered that, although "*excitability*" is not incorrectly denominated a property of the nervous centres, it is in reality only the medium through which appropriate exciting causes operate upon the material organ, in causing its functions to be roused into activity. The *individual* functions will be discussed in detail and under their appropriate heads.

As far as we are capable of judging from those phenomena which can be watched in operation, we may consider ourselves justified in assuming that some *stimulus* or *excitement* is essential to call into action the inherent property of nervous matter that has been spoken of, and which may be distinguished by the name assigned to it by Haller, viz., *vis nervosa*. That such is the case as regards muscular movements has been known and demonstrated long since; but it is not improbable that this principle is universal in its application. We may classify exciting causes, or stimuli, under two heads, *natural* and *morbid*, subdividing each head into moral and physical, or those causes operating directly on the nervous centre, and indirectly on the nervous periphera. Now it is clear that the *mental* influence by which we actuate or control muscular motions is direct in its operation: it is true that the condition of a muscle must be made known to the brain in the first instance, but this cannot be said to act as a stimulus to the nervous centre; the *desire*—the *will*, is the real exciting cause which produces the manifestation of effects totally independent of any peripheral impression. Not so, however, with those functions and phenomena over which the will has no direct influence: they may be regarded as the result of an exciting cause operating on the extremities of the supplying nerves, and thus indirectly stimulating the axis or axes to the developement of the requisite form and amount of vis nervosa.

All organs may be stimulated naturally or morbidly. The ordinary quantity of carbonic-acid gas collected in the lungs is the natural stimulus to ordinary respiratory acts; whilst an undue collection of the same gas, inhalation of irritating vapours, and other causes, produce forced or violent acts of respiration. So likewise we are disposed to believe it is as regards secretion: a certain quantity of blood in any given organ is the natural stimulus to the secreting function of that organ; and the peculiarity of the secretion is probably rather attributable to the impression made on a certain part of some nervous axis or axes, through the intervention of the intermediate nerves, than to any peculiarity of organisation in the gland; such structural modifications appear to subserve other and less important purposes, the general type being essentially the same in all glandular structures.

For the production of sensation, a stimulus must be applied to the periphera, and thence propagated to the centre: whether, as is generally supposed, the sensorium then at once becomes cognisant of the impression, we are not prepared to decide: the curiously anomalous, but undoubted fact, that the brain itself is insensible,* would induce a suspicion that here also some reflex impulse was essential to call forth and localize sensation. Here, however, a line must be drawn, and these observations brought to a close: the subject is of too speculative a nature to enlarge upon at present; and much observation and experience will be requisite to confirm or confute that which still rests on but little better foundation than bare conjecture. It is needless to dilate upon the influence of the ordinary forms of stimuli which are employed in experiments, to render manifest the operation of the nervous energy: they may be classed under the heads of mechanical, chemical, and galvanic. To entertain the idea that any of these excitants is identical with the vis nervosa, because they are capable of producing, vicariously of normal stimuli, similar effects in some instances, is puerile. It would appear that the excitability of muscular fibre, and perhaps some latent energy of the nervous system, survive the loss of ordinary vitality, and are still capable of responding to such a stimulus as galvanism; and hence the contortions of the recent corpse, along the nerves of which an electric shock is thrown: but, as before observed, the stimulus and the inherent vis nervosa are distinct, and must not be confused. The medicinal effects of narcotics prove that the nervous system may be lulled into a state of torpor, under which it is not alive to its ordinary or normal stimuli: thus, in poisoning by opium, the patient would, if not constantly roused, sink into a deep and fatal sleep, of which the precursor is imperfection of the respiratory acts, resulting, doubtless, from the diminished impressibility of the extremities of the pneumogastric nerves, rendering them less capable of responding to the stimulus of carbonic-acid gas in the air-cells: but this subject more properly belongs to practical medicine.

In what respect, then, are the vis nervosa and vitality distinguishable? A short digression will be necessary to set this question on a right footing. However we may attempt to define Life, *i.e.* whatever terms we employ to convey a notion of the sense in which we would apply the word,—the following propositions will be admitted, because evident and incontrovertible: 1. It is a principle peculiar to *organized* matter, and altogether distinct in its operation from the physical laws (whether chemical or mechanical) which determine the condition of, or changes in, inorganic matter:—nay, further, that it is an antagonist power, by which the laws last alluded to are suspended: 2. This principle is coeval in existence with the earliest appearance of organization: it therefore cannot be spoken of as a *result* of that process: 3. It is not peculiar to any *part* of the organic whole; but appears to pervade every tissue and structure, and the blood itself: hence it follows that, though vitality is not the consequence of organization, the integrity of the mutually dependent organs is essential to the conservation and persistence of the pervading attribute of all. Now, it would appear that vitality may be more or less intensely manifested in different organs and textures—a fact apparently dependent on the extent of organization, as it is termed; or, in other words, the coincidently large supply of nerves and blood-vessels: an absence of such supply involves certain loss of vitality or death. The inference to be drawn from this fact, taken in conjunction with the primeval existence of blood-vessels and early presence of nervous matter, is, that in the blood and nerves we recognise the agents by which the principle of vitality

* Instances are not wanting which experimentally prove the truth of this assertion.

in an organism is called into operation and sustained; or, as formerly hinted, that what we term nervous influence is itself a manifestation of the vital principle —a power, in short, by which the vital and organic functions are elicited, controlled, and directed. If it be attempted to investigate the nature of vitality in the abstract, nothing but useless speculation and disappointment can result; the phenomena which prove its presence can alone offer any satisfactory return to the philosophical inquirer. That this agent is a *property* of organized matter in a state of activity, in the same way as, to use the words of a modern writer, "a yellow colour, ductility, &c., are the properties of gold," cannot be doubted; but it is surely a fallacy in the followers of this school to believe that they have here recognized all: vitality is more than a *simple property* of matter; it is a *pervading principle*—an *active law*—the *moving cause* of organic changes, upon the regularity and normal evolution of which its own integrity and persistence are dependent.

*Special Physiology of the Nervous System.*

In treating of the physiology of the cerebro-spinal system, the functions of the *encephalon* and of the *spinal cord* will severally present themselves for consideration: the *peculiar* functions of individual nerves will be discussed in their respective places, viz. after the description of the nerves to which they appertain.

The *general* functions of the encephalon may be classed under two great heads: the one comprehending those evinced by the product of physical phenomena, the other referring to the connection which exists between the brain and intellectual faculties. The following order will be pursued: first, the spinal cord, in its compound character of an independent axis and conducting medium between the nerves and brain, will be considered; then, proceeding upwards to the medulla oblongata, corpora quadrigemina, cerebellum, and cerebrum, the phenomena severally attributed to them will be reviewed; and the consideration of the faculties which constitute the mind will be reserved until the other functions have been disposed of.

The compound character of the spinal cord was not, until recently, demonstrated: and it is principally to the experiments and investigations of Dr. Marshall Hall that we are indebted for our information upon this point. In order to a proper understanding of the subject, it will be necessary to resume the thread of the narrative relating to the progress of neurological physiology.

Allusion has been already made to the discovery of the double roots of the spinal nerves, and their independent and appropriate functions, by Sir C. Bell; this was indeed an era in the history of Physiology; but this anatomist pursued his researches further, and, in his *respiratory system*, laid the foundation of that more extended system entitled by its discoverer *excito-motory*. The reader need scarcely be reminded that it required not the science of the present day to distinguish between acts which spring from the exercise of the will and those with which volition can have nothing to do: thus, it was known to the ancients as well as ourselves, that the heart's action is spontaneous—that the peristaltic action of the alimentary canal is involuntary—and that respiration is performed when consciousness is lulled to sleep; yet they had no notion of connecting these actions with different nervous centres, but sought to surmount the difficulty by referring that which they could not explain to the simple law of necessity. We are naturally prone to judge of the simplicity of an act by the facility of its performance; yet how complicated is the simplest movement of a limb, when we take into consideration the various preliminary steps before contraction of a muscle can ensue. It is essential, in the first place, that the sensorium should be rendered cognizant of the condition of a muscle before it can be influenced by the will. This communication from circumference to centre is apparently independent of sensation; a mysterious sort of electric telegraph, the complex operation of which must be very much augmented when the required movement, instead of being simple, is varied and rapid, as *e. g.* in the execution of a quick and difficult passage on a musical instrument. The next step in the process is one concerning which we can know nothing,—viz.: the appreciation of this impression by the intelligent part of our nature; or that which follows,—the means by which the will controls the muscles. It is evident that the *moral* must, at some stage, become converted into a *physical* influence; and it is most probable that this transition occurs at what is presumed to be the confines of our intelligent organ, the brain. How then does the moral set in motion the physical impulse propagated along the conducting nerves? according to what physical law are the muscles impressed so as to be called into action? All these questions are yet, as they are likely to continue, unanswered; and we must be satisfied still to speak of much respecting which we are ignorant. But to return;—reflections, possibly of a nature somewhat allied to the preceding, may have induced Sir C. Bell to attempt the task of at least simplifying the operation of nervous influence, by classifying and arranging results in reference to their sources or axes of reflection. He states that his attention was first arrested by observing the origin of certain nerves from a distinct portion of the upper division of the spinal cord, near together and in the same line; these were the fourth, facial division of the seventh, and the eighth cerebral. A consideration of the distribution of these nerves, and subsequent experimental investigation, gave him the result, that "they excite motions dependent on the act of respiration." He further conjectured the probable extension of his so-named respiratory track throughout the spinal cord, below the medulla oblongata as well as in it. The inference drawn from these data was just, viz.: that the activity of the respiratory organs is ordinarily independent of the brain, having for its source the medulla oblongata. This was the truth, but not the whole truth; and we can scarcely help regretting that Sir C. Bell did not generalize still further before he attempted to cast his observations into the form of a system, and confined that system to the respiratory apparatus. Thus, then, we have seen how a rational explanation may be given of that which previously only stood as a foolish and glaring paradox, viz.: "that a person labouring under apoplexy will *perceive* the uneasy sensations transmitted from the collapsed lung, and will *voluntarily* employ the muscles of respiration to relieve them, *without* being at all conscious of such perceptions having occurred." The respiratory muscles *may* act under command of the will, but they are *ordinarily* excited to action by an impression made upon the peripheral extremities of certain of their nerves.

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It has been remarked that Sir C. Bell selected the respiratory apparatus, and confined his observations to the muscles of this system. The phenomena were here apparent; and he believed the muscles connected with respiration were alone susceptible of that form of spontaneous action. That this belief was erroneous has been more recently proved by the discoveries of Dr. M. Hall and Professor Müller; although it is but just to give their due to some amongst the physiologists of the last century, especially Whytt and Prochaska, who doubtless reasoned correctly on the phenomena they observed, and stated their conviction that involuntary acts were referable to nervous sources, independent of the centre of volition: the latter even speaks of *reflex* actions; but there is no evidence of their possessing a *clear* and *satisfactory* idea of those *excited* acts being *perfectly* distinct from sensation; nor did they attempt specifically to localize or ascribe to their appropriate relative axes, the different species of muscular movements: but even here both of these physiologists made shrewd conjectures which were so far in advance of the state of the science in their own time, that their writings were never thoroughly appreciated until very recently—a true test of real and substantial merit in an author.

Having arrived at the limit of Sir C. Bell's speculations, we now pass on to the more extended system developed by Dr. M. Hall and Professor Müller. This part of our subject may be introduced by the very natural inquiry, "Is the respiratory system solitary in the peculiarities here alluded to?" It has been the aim of the last-mentioned physiologists to exhibit the appropriateness of an interpretation, analogous to that which had been applied to the respiratory system *exclusively*, by which to construe many otherwise obscure and anomalous phenomena in the muscular system *generally*; in short, to prove the compound character and properties of the spinal cord. One or two experiments, quoted from Dr. M. Hall's lectures, will illustrate this subject.* A horse, having been felled in the usual way with a pole-axe, became totally insensible in consequence of the deep lesion of the brain: respiration, however, continued, but no suffering was evinced on lacerating or pricking the skin; when the eye-lash was touched with a straw, the eye-lid was forcibly closed by the orbicular muscle: an analogous result followed irritation of the anus. The upper part of the spinal cord being destroyed, together with the medulla oblongata, through the orifice made by the pole-axe, violent convulsions ensued, followed by cessation of respiration, and a motionless condition of the eye on the application of stimuli. Again, the spinal marrow of a living frog was divided below the occiput; all voluntary and spontaneous motion ceased; when the toe was pinched, the extremities were moved: destruction of the spinal marrow was in like manner succeeded by total loss of excitability. Further, a turtle having been decapitated in the usual manner, all the above phenomena were evinced in a marked degree in both the head and trunk, but ceased immediately the nervous centres were severally removed from the skull and spinal column. Similar evidence of the independence of the spinal cord may be procured from patients labouring under apoplectic attacks, or suffering from severe injury of the brain or fractured spine with compressed cord.

Thus it will be perceived that this system consists of similar essential parts to that under the control of the will, viz.: a centre or axis, and double filaments, conveying impressions in opposite directions; the centre of reflexion being the spinal cord, or that portion which we may call the *true* spinal marrow, to distinguish it from that division which is palpably only a conducting medium between the nerves and brain; in fact, a continuation of the former to the latter. It may be moreover inferred from the experiments which have been related, that the *spinal* axis consists rather of a series of centres or sources of nervous influence than as one whole: thus each portion is the *independent* axis by which impressions are received, and from which they are reflected along the nerves which terminate in, or spring from, any given point. It is by no means intended to deny that the voluntary and excito-motory systems may act coincidently: on the contrary, the co-operation of the two is frequent, and often essential to the integrity of their relative functions.†

We now pass on to the consideration of the medulla oblongata as the probably exclusive seat of simple excited respiratory movements. The fallacy of the paradoxical opinion held by Mr. Mayo and Dr. Wilson Philip, viz., that the acts of respiration are entirely *voluntary*, has been already shown. The hypothesis of Legallois, Flourens, and Sir C. Bell, was nearer the truth, for they attributed the respiratory movements to the medulla oblongata as their *source*, but at the same time believed this division of the spinal cord was their *primum mobile*—that the acts were spontaneous. It would be superfluous to disprove this opinion by any lengthy argument: pathology and experiment combine in demonstrating that the movements of respiration are essentially *excited* acts, although frequently modified by volition; and even then, the exercise of the will receives its impulse from sensations of uneasiness.

It is a fact, that injury to or pressure upon the spinal cord, as in fractured spine, above the third cervical vertebra, produces instantaneous death. This result was, and indeed still is, very generally attributed to compression of the cord *above* the origin of the phrenic nerve, under the supposition that thus the influence it was presumed to derive from the cerebrum was cut off, and that thence resulted the paralysis of the diaphragm. This is not however the true explanation: the fact is, that the axis or centre of excited motor power is thus crushed, and its function of course annihilated. Mark the different result, when the seat of volition, the cerebrum, is deeply injured and paralysed: respiration still continues, though the sufferer lie unconscious and dead to external objects. Again, the acts of respiration may be replaced by artificial means of supplying air, as evidenced in Hook's remarkable experiment, as related in the *Phil. Trans.* for 1667, p. 539. A stream of atmospheric

* *Lectures on the Nervous System*, 1836, p. 18, *et seq.*

† All *compound* nerves are both excitor and motor. Of the *cranial* nerves, the following table shows the relation of excitors and motors:—

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|---|---|
| *Excitor.* | Ganglionic portion of the fifth. |
| | Pneumo-gastric, (non-motor portion). |
| | Glosso-pharyngeal. |
| *Motor.* | Motor nerves of the eye. |
| | Non-ganglionic division of the fifth. |
| | Facial. |
| | Muscular portion of pneumo-gastric. |
| | Spinal accessory. |
| | Lingual motor. |
| | Glosso-pharyngeal. |

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air was driven through the trachea and lungs, and allowed to escape by incisions made in the pleura of a living dog: "The animal made no efforts to inspire whilst this stream was continuous, but when it was interrupted, the efforts of inspiration were violent and convulsive." What then is the medium of communicating the necessary stimulus to the medulla oblongata? There seems very little reason to doubt that the stimulus is the collection of carbonic-acid gas in the air-cells, producing an impression on the peripheral extremities of the pneumo-gastric ramifications, and thence conveyed to the medulla oblongata, from which the motor reflex influence is propagated along the phrenic and other respiratory nerves to their destined terminations. That the pneumo-gastric is the agent seems to be proved by an interesting experiment. If these nerves be divided, and an animal (say a dog) be immersed in water, he dies without effort at respiration. That the converse is the case is well known.

*Spinal Cord.*—In recapitulating what has been said, the following may be enumerated as the functions of the medulla oblongata and spinal cord, or, in other words, the *true* spinal marrow. 1. It has the property of receiving impressions conducted along the nerves of sensation, and of reflecting motor power along the motor nerves, without the cognizance of the sensorium: and further, it would appear from experiment, that these reflected motions are most prone to be excited in motor nerves originating from near the same spot in which the incident sensitive nerve terminates: thus, irritating the sole of the foot produces most readily contraction of the muscles of the leg; but this is not invariable. 2. It exerts a constant influence over the muscles generally; preserving some, as the sphincters, in a continuous state of tension, and giving tone to the muscular system generally. This property, when abnormally excited, as in trismus and tetanus, gives rise to continued or occasional spasmodic action of the muscles; a fact further illustrated in cases where the equilibrium of antagonist muscles is destroyed by disease or accident exclusively affecting one set: distortion results from the unresisted action of the sound muscles. 3. It appears to be the source of the sexual *power*. Lastly, the *true* spinal marrow would appear to be the centre or source of *all* motor power; thus possessing the double office, in *voluntary* movements, of receiving and propagating centrifugally the influence of the *will*, derived from the centre of volition, the cerebral hemispheres, by which its own motor property is called into activity. Professor Müller believes that the cord is capable of originating automatic movements; but this is questionable, and it seems probable that the true explanation may be met with in trifling and accidental sources of excitement which have escaped observation.

The foregoing properties have been noted as common to the medulla oblongata and rest of the medulla spinalis; but the former is likewise the seat of other and very important functions. Before proceeding to enumerate them, it will be desirable to indicate the parts included under this division of the encephalic mass.* It may be premised that the central position of the medulla oblongata, and the evident co-relation which it bears to both the spinal and cephalic axes, very much enhances the importance of this question, as well as an exact knowledge of the course and distribution of the medullary columns which compose it. 1. The *corpora pyramidalia*, consisting of direct and decussating fibres; they form, above, the lateral boundaries of the anterior fissure, the latter fibres of the one side joining the former of the opposite. The fibres of the pyramid pass between the transverse fasciculi of the pons to join the crura cerebri. 2. The *corpora olivaria*, formed by the expansion of the anterior grey columns of the cord: the white matter which it encloses and which surrounds it, gives, when the olivary body is cut through, the appearance called *corpus dentatum*. Burdach also describes other deep fibres on either side of the corpus olivare, under the title of *fasciculi siliquæ*: both portions appear to belong to the anterior columns, the internal accompanying the corpora pyramidalia to the crura cerebri, the external passing around the processus cerebelli ad testes, to the base of the corpora quadrigemina. There is also the medullary investment of the lateral and posterior columns, constituting principally the *corpora restiformia*, which are the processes passing from the medulla oblongata to the cerebellum. Lastly, Burdach, and Müller after him, describes a *fasciculus gracilis* bounding the posterior fissure, and passing towards the fourth ventricle and *fasciculi teretes* lying between the corpora restiformia in the floor of the fourth ventricle, and subsequently bounding the aqueduct of Sylvius anteriorly and inferiorly.

*Medulla Oblongata.*—The medulla oblongata has been already spoken of as the seat of the respiratory movements: evidence of the other functions which appear to be localized in it is almost exclusively drawn from experiments, of which those of Flourens and Hertwig* deserve more particular mention: the results obtained by the latter confirm, in nearly every particular, the conclusions of the former. 1. Flourens has shown, by repeated experiments in which he has removed the *cerebral* hemispheres, that the animals still possessed the power of performing *voluntary movements*, and of even directing those movements with regularity; but requiring to be roused to make the exertion. 2. The medulla oblongata is the principal, probably exclusive, seat of the faculty of *sensation*. This conclusion is not only drawn from the phenomena observed in experiments, but is confirmed, as Professor Müller has remarked, by the anatomical fact that all the cerebral nerves, with the exception of the first and second, are connected with it, or with its prolongations in the brain. Flourens believed that the cerebral hemispheres were the seat of sensation; but Cuvier drew an opposite conclusion from the same experiment, coinciding with Magendie and Desmoulins, who obtained as results to their observations, that removal of both cerebral and cerebellar hemispheres, exclusive of *all* the parts belonging to the medulla oblongata, does not annihilate sensation. The *specific* sensations of sight and smell are destroyed; but these senses are essentially independent of, and differing from, the consciousness of common sensation. Müller confirms,† by his observations, the preceding remarks; stating that, though stupor supervenes on removal of the cerebral hemispheres, obvious evidence of sensibility is manifested,

* Burdach's description is followed; to whose work, *Von Bau und Leben des Gehirns*, reference may be made for further information.

* *Recherches Expérimentales sur les Propriétés et les Fonctions du Système Nerveux; par* P. Flourens, Paris, 1824. *Exper. de effect. læsionum in partibus Encephali*, Berlin, 1826. The reader may also consult the *Anatomie des Systèmes Nerveux, par* F. Magendie et A. Desmoulins, Paris, 1825.

† *Opus citatus.*

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which is readily distinguishable from reflected or excited movements. The subject of the mutilation will rise from the recumbent posture, and is capable of progression, or, if a bird, can fly. Sensations, in short, appear to excite movements which are alike undirected by mental effort, or are the mere product of reflected impressions.

A natural question may here be asked :—How is it, if such extensive mutilation does not annihilate voluntary motion and sensation, that such comparatively trifling læsions as are produced by depression of a fragment of bone, or extravasation of a clot of blood on or into the cerebral hemispheres, should cause total suspension of the above-mentioned functions? The only reasonable explanation appears to be this; that the incompressibility of the brain and unyielding nature of the skull render the uniform diffusion of pressure throughout the whole encephalic mass, a necessary consequence of such condition affecting any single point. That the symptoms are not to be accounted for by laceration of the texture of the brain alone, is sufficiently proved by the extensive læsions which may occur without their concomitant presence, as well as by the relief obtained on removal of the source of pressure.*

*Corpora Quadrigemina, &c.*—It now remains that the other divisions of the encephalic centre be severally considered in relation to their functions; these are the corpora quadrigemina, optic thalami, cerebellum, and cerebral hemispheres,—or those parts which are usually included under the generic title of brain. The *Corpora Quadrigemina* of mammalia, and the *Optic Lobes* of birds, reptiles, and fishes, together with the *Optic Thalami* in man and the higher animals, appertain to the sense of vision. The experiments by which the fact is proved are those of Magendie, Desmoulins, and Flourens, and more recently of Hertwig; and the results of the latter physiologists agree in the following points. If the læsion of the above-mentioned structures in mammalia or birds is partial and confined to one side, it is accompanied by correspondingly partial loss of power and blindness on the *opposite* side: the loss of vision is not, however, permanent, nor does it appear to be necessarily accompanied by paralysis of the iris; but if the mutilation extend to deeper læsion or complete removal of the optic lobe, then the properties of both iris and retina are wholly and irremediably destroyed.† The above experimenters also remarked that the partial læsion alluded to caused the subject of the experiment to revolve on its axis. From the foregoing description it will be perceived, that the corpora quadrigemina have nothing to o with the mental acts of memory, consciousness, &c.; they appear to remain intact.

*Cerebellum.*—Rolando first noticed the connection between diminution of the muscular movements and læsion of this division of the brain: there was, he observes, neither loss of sensibility nor stupor induced; and though the animal seemed perfectly conscious of all that was going on around, yet it was incapable of exerting the muscles, and lay perfectly quiet. In like manner, when one half of the cerebellum was removed, the animal fell to the same side, the corresponding extremities becoming paralysed. The conclusions of this anatomist it is unnecessary to detail, for they were fanciful and unfounded.* M. Flourens gives the following account of the results obtained from his experiments :—"An animal deprived of its cerebellum loses all equilibrium, all *coordination*, all reciprocal relation (*correlation*) in its movements. Nevertheless, all the parts of such an animal, the head, the trunk, the extremities move, and move with vigour; but since there is no longer any concurrence, any disposition or *mutual* understanding, if one may venture so to express it, no result is obtained. Such an animal as this no longer walks, no longer flies, no longer preserves the standing posture; not that it has lost the use of its feet or its wings, but because the combining and directing principle of its legs and its wings no longer exists. In a word, all the partial or individual movements are continued; the combination alone of these movements is lost."† It may be further observed, that Flourens found no pain evinced by an animal whilst the cerebellum was being removed: volition as well as sensation seemed perfect; and sight and hearing were not interfered with. Partial injury appeared to be reparable.

Those who are at all familiar with craniology need not be reminded that Gall locates the sexual passion in the cerebellum, an opinion which seems to have had its origin, as it appears to derive some support, from the more frequent coincidence of læsion of the cerebellum than of the cerebrum with affection of this passion. There are, however, many facts, both physiological and pathological, which render this hypothesis very questionable. Thus, there appears to be no corresponding ratio existing between the developement of this passion and the cerebellum; and the occipital region in the monkey, for example, is relatively less capacious than in man. With regard to pathology, it is unnecessary to individualize cases to prove or disprove the theory alluded to; there is no doubt that cerebellar læsions and affection of the sexual desires have frequently been discovered as co-existent; but the narration of one such case as Cruvelhier details in his *Pathological Anatomy*, and to which recent writers have naturally referred in discussing this question, goes far to overthrow the doctrine which Gall has attempted to establish. The case in question is that of a girl who died at the age of eleven, in whom, though conjoined with great physical weakness and want of general developement, as well as dulness of intellect, the sexual passion was precociously and strongly marked: yet in this child, the space beneath the tentorium was occupied by serum, and in place of the cerebellum, there was a simple membranous band crossing the summit of the medulla oblongata, and connected laterally with a swelling not larger than a nut.

*Cerebrum.*—Lastly, we proceed to direct attention to the part which the *Cerebral Hemispheres* play in the production of physical phenomena, and this we shall find to

* There are some interesting instances on record of encephalous fœtuses, which lived for some hours, or even days: see Lawrence, in *Med. Chir. Trans.*, vol. v. p. 166; also Lallemand, *Observations Pathologiques*, &c., p. 86; and Olivier, *Traité de la Moëlle Epinière*, p. 155. In Mr. Lawrence's case, the medulla spinalis was continued "for about an inch above the foramen magnum, swelling into a small bulb." Olivier says that, in his case, (the child survived six hours,) the medulla oblongata was likewise absent. But we must not theorize on one instance.

† In complete amaurosis, paralysis of the iris is not an essential concomitant; but in the experiment alluded to in the text, the circle of reflex motion is interrupted by the injury or destruction of the excito-motor axis or centre.

* Allusion is made to his hypothesis, that the cerebellum was a galvanic pile for the generation of the "vis nervosa," an idea obtained, it would appear, from the lamellated disposition of its structure.

† *Op. cit.* p. 211.

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Zoology. be limited to their operation as the agent and seat of the intellect. Here again the experiments of Flourens and Hertwig are the most satisfactory; and as those of the latter agree in every essential particular with the earlier observations of the former, the details here given will be selected, as before, from the account of M. Flourens.

The united experience of all ages has agreed in admitting the coincidence of large cerebral developement with correspondingly extended mental endowments; and this observation, it need scarcely be remarked, has nothing in common with the cranial mapping of the phrenologists. The means possessed of procuring practical information in relation to the effects of injuries of the *cerebral* lobes in man are, owing to their position, far more extensive than that afforded by other parts of the encephalic mass. Frequent opportunity is thus afforded in surgical practice of watching the symptoms which result from lesions of the cerebral hemispheres by fractures of the skull. The common result of such injury is a condition resembling, and in fact identical with, apoplexy. But from these observations not any just or accurate conclusions can be drawn in regard to the *exclusive* functions of the seat of injury; and as an explanation of the phenomena of compression has been already offered, it is unnecessary to add any further remarks upon the subject.

The duplex character of the cerebral hemispheres, as indeed of the whole brain, is of great importance in preserving the integrity of their functions: for the experiments of Flourens seem to prove that the one side may and will perform the functions of the other when injured. This is a fact likewise proved by the result of extensive læsions, and removal of portions of the brain in the human subject. These observations further uniformly confirm the interesting phenomenon, that the brain itself is insensible. When deep wounds of the brain are probed, or when large masses of either hemisphere are sliced off in individuals who are perfectly conscious and sensible, no complaint has been uttered, save where the membranes or cranial parietes were irritated. Further, neither convulsions nor muscular contractions follow simple læsion of the cerebral hemispheres. Flourens remarks that the intensity and duration of some symptoms connected with these injuries are very variable. When he removed one hemisphere in a pigeon, blindness of the opposite side ensued, the contractility of the iris, however, continuing: the sensorium was destroyed, but the seat of reflex action remained entire. Great feebleness was likewise evinced by all of the opposite side of the body to that injured; this phenomenon, on the principle of vicarious performance of function already alluded to, was soon relieved; and the various evolutions of walking, flying, &c. were well performed. In another experiment, in which Flourens removed both hemispheres, the animal was deprived of sight and hearing, and of spontaneous motion. The condition, in short, resembled stupor or deep sleep. The animal was capable of motion, but only when urged or irritated; and the experimenter not inaptly compares the condition induced to that of a continuous sleep, without even the power of dreaming.

Thus it is evident, that the cerebral hemispheres are those parts of the brain by which the mind communicates with external nature, and by which the impressions from the world around us, are either directly or indirectly received. We say directly or indirectly, because we have already shown that other divisions of the brain are importantly concerned both as recipients and active agents; but it is to the cerebral hemispheres alone that the function of ultimately receiving sensorial impressions, the faculty of perception, and subsequently acting upon them by the immaterial agent, is confined. Thus then is the circle completed: the faculty of *attention* prepares the way for the external impression to be duly appreciated; *perception* then becomes merged in the *idea* that follows, and *volition* acts upon the suggestion of the latter. Not infrequently, however, long intervals elapse between the different stages of this physico-mental operation, especially between the perception of the impression and resulting act; as, for instance, where the subject of the perception is of a complex or novel character: then are the various faculties of the mind brought into operation, such as memory, comparison, judgment, upon the soundness, integrity, and cultivation of which the resulting act is wholly dependent for its own rectitude and value.

Having now disposed of what may be styled the *physical* functions of the brain, that which remains for discussion of the physiology of this organ will naturally resolve itself into two divisions; the one comprising the question of the relation which the capacity of the mind bears to the developement of the brain, and the other the consideration of the mental faculties, and their relation to each other, and the objects which excite or occupy them. These two subjects form essentially distinct branches of study; the former being specially physiological, whilst the latter is denominated "mental philosophy." It is proposed to offer a few observations on each of these divisions, and the reader is referred, for further information on the latter extensive subject, to works especially devoted to the analysis of the mind.*

*Relation of Mental Capacity to Cerebral Developement.*

We cannot refrain a smile when we read the quaint and groundless hypotheses of our forefathers, in their attempts to distribute and localize the metaphysical functions of the great central organ of the nervous system. Yet, absurd and utterly devoid of proof as were their speculations, they were, at the least, confined to the discovery of the locality occupied by faculties which are the natural attributes of man, and not of such as are the offspring and result of the factitious relations consequent on civilization and society. From an early period it has been the natural aim of the physiologist to attempt an elucidation of the varied functions of the brain by an appeal to its intimate structure: yet but little that is satisfactory has resulted from this investigation. It is true that the course of the component fibres has demonstrated the connection of the spinal cord with the encephalic centre; and this information has been justly employed in proving the relation in function which these several parts bear to each other; but the test of actual experiment, the observation of morbid changes and abnormal developement, and the relative proportion of different parts in different animals, have done more towards unfolding the uses of the nervous centres than simple dissection. The observations of Dr. Macartney, read before the British Association at Cambridge, are, perhaps, the most valuable contribution relating to the

* The works of Dugald Stewart and Abercrombie afford compendious and interesting outlines of the intellectual faculties. Dr. Prichard's *Physical History of Man* contains much valuable and original information on the subject of the relative developement of the cranial cavity in different nations.

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structural anatomy of the brain that we have had for some time. He describes the interlacement of the fibres as most intricate, establishing a free communication between different parts of the organ, and resembling in arrangement the ultimate structure of the nervous plexuses: the commissures, we cannot doubt, are destined for the purpose of permitting an unity of operation between the corresponding portions of either side of the cerebral mass; but what the individual functions of each commissure may be is yet a mystery. Still the main question remains unsolved—untouched; what relation does all this intricacy of structure bear to the operations of the mind? and whether we think and speak, with Willis and others, of "animal spirits," or with Hartley and many of our modern physiologists, of "vibrations and vibratiuncles," agitating and putting in motion the fibrillæ of its "mystic web," an impartial consideration and appeal to common sense cannot fail to convince us of the utter insufficiency of these mechanical hypotheses in explaining the difficulty.

The relative developement of the nervous masses, and the degree of intelligence exhibited by the lowest classes of animals, is a subject which even the phrenologists have not attempted to explore: we must therefore content ourselves with indicating the more prominent points which characterize proportional developement of structure and function in the central nervous organ of animals which possess a brain, where a correspondence may be distinctly traced, and a comparison fairly instituted. At the very outset of this inquiry, however, a difficulty presents itself, viz., are we to include what we term Instinct in this consideration, and, if not, what phenomena are referable to instinct and what to mental intelligence? To define instinct were needless; every one is familiar with its effects, and satisfied of the wise and benevolent purposes for which it is bestowed, as well as of the admirable and unerring results with which its operation is attended. An illustration or two will serve to exemplify its agency, and contrast it with reasoning intelligence. It is the impulse of instinct which prompts an animal to provide against evils which it has never experienced; to seek shelter and food; to secure and nourish its offspring: in these provisions who can doubt the direct endowment of the creature with faculties appropriate to its wants? an endowment as prominently marked in the bee and ant, aye,—and in the most minute animalcule,—as in the burrowing fox or soaring eagle. As we might almost surmise *à priori*, instinct bears an inverse proportion in its developement to that of reasoning intelligence; and man, who stands proudly pre-eminent for the perfection of his intellect, sinks, when deprived of its aid, into pitiable helplessness. The fact that the same law of inverse proportion in relation to instinct and *physical* developement likewise holds good, will justify our disposing at once of this faculty, and confining our inquiry to the phenomena which bear the characteristic stamp of reasoning; the power of arriving at just conclusions from given data, involving the existence of a capability to extend experience, as distinguished from the sagacity of foreknowledge or direct endowment.

We may accept then, as general, the law of proportional developement of brain and exalted powers of reasoning. But the subject requires a somewhat closer investigation as a security against error; the reader is therefore reminded that it is to the cerebral hemispheres exclusively that the above axiom refers. The progressive *complication* of structure, as we ascend the scale, is not so apparent; but this, doubtless, arises from our utter incapacity to appreciate the extent of complexity in what appears a simple mass of medullary and cineritious matter, arranged in bands or fibres interlacing in every direction. Here again a natural question arises: What are the faculties, independently of instinct, which the lower animals possess in common with man? A thoughtful observer can scarcely doubt that they possess the power of acquiring knowledge from experience, and even of contriving suitable means for achieving particular ends; they have memory, and many facts would seem to render it probable that imagination is not denied to them: further, their means of mutual communication by which they are enabled to act in concert cannot be questioned.* Yet to these efforts of intellect a limited boundary is fixed,—a barrier which can never be overpassed. But in man the prominently characterizing feature is, his capability of extending his information by his capacity for the retention of many and varied impressions; "and," as Dr. Roget observes,† "the vast range of the associating principle which combines them into groups, and forms them into abstract ideas." Of this power the lower animals seem almost or altogether destitute.

With regard to the external configuration of the brain in man and other vertebrate animals, this general remark may be made: that in the former, all the parts belonging to the latter are present, whilst many parts which exist in man are either very small or altogether absent in the inferior animals. But it is in the cerebral hemispheres that the most marked difference and variety exists. Thus in many animals there is no distinction of the brain into lobes; and in many orders, the carnivorous, ruminant, and others, only two lobes are distinguishable. Again, in many mammalia there are scarcely any traces of convolutions; and where they are distinct, as in carnivorous and ruminant animals, and even in the quadrumana, they are far more simple in their arrangement than in man.

If we attempt to apply the test of proportional developement of the *entire* brain in its *relative* bearing to the general mass of the body, we should be deceived in expecting that man would then stand at the head of the list; there are exceptions to this rule; and in *positive* or absolute size of brain, man is exceeded by the whale. How are we to explain this apparent paradox? Let it not be forgotten that the brain has other functions besides those which are now under discussion: and a brief consideration will point out the necessity of large developement coincident with perfection of these other functions. Allusion is more especially made to the means which animals possess in common with man of communicating with external nature. Now the senses of most animals are either in part or altogether more highly developed than in man: in hearing, sight, sense of smelling, and accuracy of feeling, the last most rarely, he is surpassed by those animals which his reason teaches and permits him to employ as subservient to his necessities or pleasures. But if those parts of the brain are compared which appear to be the exclusive seat of the intelligent part of our nature, man stands prominently first, without

* For facts and anecdotes establishing these statements, the reader is referred to works on natural history.

† *Bridgewater Treatise.*



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Zoology.

regard to greater positive or relative developement of that organ as a whole in other animals: "in the proportion," as Soemmering has remarked, "as the organ of reflexion exceeds that of the external senses, may we expect to find the powers of the mind more diversified and more fully developed."

The following table from Carus's *Comparative Anatomy* shows, in some animals, the *relative* developement of the brain to the whole body:—

| | | | | |
|---|---|---|---|---|
| Pike . | as | 1 | to | 1305 |
| Salamander | ,, | 1 | ,, | 280 |
| Tortoise . | ,, | 1 | ,, | 2240 |
| Pigeon . | ,, | 1 | ,, | 91 |
| Eagle . | ,, | 1 | ,, | 160 |
| Rat . | ,, | 1 | ,, | 82 |
| Sheep . | ,, | 1 | ,, | 351 |
| Elephant . | ,, | 1 | ,, | 500 |
| Gibbon . | ,, | 1 | ,, | 48 |
| Simia capucina | ,, | 1 | ,, | 25 |

Soemmering says the maximum weight of a horse's brain is one pound seven ounces; and Müller gives the weight of a whale's brain in the Berlin Museum as five pounds five ounces one drachm: the animal measured seventy-five feet.

It now remains, in completing this division of the subject, to make a few observations on the relative developement of the brain in the Negro, as compared with the European and monkey. For this purpose the interesting papers of Professor Tiedemann have been consulted: they were read before the Royal Society in 1836, and have since been published in a collected form.*

It is but recently that the question involving the relative natural endowments and intellectual capabilities of the Negro and European races of mankind has ceased to be a matter of mere speculation: the investigations have lately assumed a more practical character, because the inquiry has been aided by actual observation, and comparison of physical developement as well as mental capabilities. The present object is simply to place before the reader the result of the two inquiries regarding physical developement, which occupy the principal place in Professor Tiedemann's *Dissertation*; viz., "Is there any material difference between the brain of the European and Negro; and does the brain of the Negro bear more resemblance to that of the European or ouran-outang?" The maximum and minimum weight of the human brain, as given by Soemmering, has been already noticed; yet, simple as the subject may appear as a mere matter of experiment, there are scarcely two authors who agree regarding the mean weight of the brain in man. This is probably in great measure referable, as Dr. Clendinning has remarked,† to a neglect of taking into account the effects and morbid changes produced by disease; increased weight of the encephalon being, for example, as the above author states, an "usual effect or concomitant of morbus cordis." In comparing the results of Soemmering, Sims, Hamilton, and Tiedemann, it will be found that a weight somewhat exceeding four pounds is the average of the healthy male brain at its largest developement; and that the female brain is some three or four ounces less. There is again a curious discrepancy in the results of inquirers respecting the period of greatest developement of the brain; Soemmering placing it at the third year, Gall and Spurzheim at the fortieth: Sims says the weight fluctuates, and Tiedemann believes the seventh or eighth year is the period of maximum weight.

* *Das Hirn des Negers*, &c. Heidelberg, 1837. 4to.

† Crooman Lectures, in *Medical Gazette*, 1838.

It was asserted by Camper that, besides the acute facial angle, the Negro has a smaller brain than the European. This assertion Tiedemann (who, it may be noticed, is throughout his paper the benevolent advocate of our swarthy brethren) denies; and brings forward instances in proof of his position. His data are, however, but limited, and his deductions a little forced, as may be seen by reference to his tables of measurements, of which one, reduced by taking the averages, is appended: it exhibits a comparative view of the measurements of the cerebrum in four Negroes, seven European males, and six European females.

| | | | Inch. | Lines. |
|---|---|---|---|---|
| Average length in | 4 | Negroes . | 5 | 11 |
| ,, | 7 | European males | 6 | $2\frac{1}{8}$ |
| ,, | 6 | do. females | 5 | $10\frac{3}{8}$ |
| Average breadth in | 4 | Negroes . | 4 | $8\frac{1}{8}$ |
| ,, | 7 | European males | 5 | $1\frac{1}{7}$ |
| ,, | 3 | do. females | 5 | $4\frac{1}{8}$ |
| Average height in | 3 | Negroes . | 2 | $11\frac{3}{8}$ |
| ,, | 7 | European males | 8 | 4 |
| ,, | 4 | do. females | 2 | $9\frac{3}{8}$ |

The result of Professor Tiedemann's dissections of the brain in the ouran (two specimens in the College of Surgeons) have induced him to point out the following as the distinctive marks of difference between it and that of the Negro. "1. The cerebrum is absolutely and relatively to the mass of the body, smaller, shorter, narrower, and more flattened; 2. It is smaller in relation to the nerves; 3. The cerebral hemispheres bear a smaller proportion to the spinal cord, medulla oblongata, cerebellum and corpora quadrigemina; 4. There are fewer convolutions and shallower sulci." A fair inference from these observations regarding the points at issue may be summed up in the following statement:—1. In no way does the encephalon of the Negro differ from that of the European, excepting that the mean size of the *cerebral* hemispheres is somewhat less in the former; 2. The brain of the Negro bears no more resemblance to that of the ouran than the brain of the European does, excepting in the more symmetrical arrangement of the convolutions in the two hemispheres; and even this appears questionable. We may hence conclude, as will be more fully shown in a future section,* that the Negro has but little in common with the ape; and that he only differs from his European brother in not being, in intelligence, his perfect equal.†

### *Mind.*

A brief sketch of the intellectual faculties will conclude the present division of the subject. The course usually pursued by writers on mental philosophy is that which presents itself as most natural; viz., a consideration of each faculty as it is called into operation by external impressions. Thus, Perception first claims attention. Many and fanciful have been the hypotheses

* The reader is referred to the section relating to the distinguishing characteristics of man; where the peculiarities in the conformation of the skull in different races, together with its proportional developement in relation to the face, will be discussed.

† The original treatise may be consulted for further information: also critical articles in the *British and Foreign Medical Quarterly Review*, vol. viii., and the *Phrenological Journal*, No. 54, which contain strictures on the professor's deductions.

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Zoology. from the earliest period of philosophical investigation until a comparatively recent date, on which attempts have been grounded to delineate the means by which an external impulse is conveyed to, and leaves its impress upon, the sensorium: and nothing perhaps has operated more in embarrassing the question than a fruitless effort to explain the *modus operandi* by reference to the analogous process in the physical world. Yet the truth is, that all the guidance we can derive from this source, is the observation of an uniform connection between *cause* and *effect*: for, paradoxical as it may appear, our knowledge of this simple relation is alone gained from experience, whence we derive a perfect confidence in those connections which we have constantly witnessed. Thus the various theories which have been adopted for the purpose, as it were, of gradually spiritualizing the impression of matter upon the external senses, (as in the action of light upon the eye, and atmospheric vibrations on the ear,) and thus fitting them to be received by the sensorium and converted into ideas, are fanciful and groundless: it is but a vain attempt to seek to explain that which is essentially immaterial, by material steps, but leaving the true object of investigation as distant as ever. It is to Dr. Reid that we are chiefly indebted for exposing the fallacies alluded to; and the simple extent of our information, or rather ignorance, upon the subject may be summed up in his statement, which is to this effect:—"The mind is so formed, that certain impressions made on our organs of sense by external objects are followed by correspondent sensations; and that these sensations (which have no more resemblance to the qualities of matter than the words of a language have to the things they denote) are followed by a perception of the existence and qualities of the bodies by which the impressions are made; and that all the steps of this process are equally incomprehensible."* It is, however, no matter of mere speculation that our knowledge is derived from external nature by the aid of our senses, it is a fact known to us by experience.

When an impression is made on the sensorium, is it necessarily *perceived?* a moment's reflection will supply many instances where such is not the case. A clock may strike the hour, or the eye may rest intently on the dial, without the organs appealed to being conscious of the sound or the position of the hands; yet no one doubts that the impression was made as usual on the auditory nerve and retina; that the clock was heard to strike—that the direction in which the hands pointed was seen. These and similar phenomena clearly imply the existence of a faculty by which we are enabled to direct the mind, so as to preserve and, as it were, to appropriate an impression: this faculty is Attention. Dr. Reid treats of attention according to its relation to things external, and to the subjects of our consciousness, which he severally names Observation and Reflection. This faculty is, more than any other, under the control of the will, and therefore most open to cultivation. That some individuals naturally possess the capability of applying their attention more readily than others cannot be doubted; but all are accountable for the proper employment and training of this faculty, whether in *observation* on external things, or in *reflection* upon fitting objects; a truth which cannot be too strongly impressed on those intrusted with the education of youth, from the earliest dawn of intelligence; for thence is the formation of good or bad habits in after-life to be dated. Zoology.

The perception of an impression, aided by due attention, yields the means of calling into activity the faculty of Conception. The independence of this faculty has been questioned by some writers: thus, the last-named author is disposed to employ it as synonymous with Imagination: he makes, however, the distinction of their holding the relation of a part to the whole, defining imagination as "a lively conception of objects of sight." Dr. Abercrombie, again, thinks conception so nearly allied to memory as to allow of its being considered as a part of it: he calls it the "memory of perception." We are inclined to adopt the distinction recognized by Dugald Stewart, who defines conception as the faculty "whose province it is to enable us to form a notion of our past sensations, or the objects of sense that we have formerly perceived." This he aptly illustrates by remarking, that the artist does not paint the likeness of a deceased friend from memory; conception makes the required face an object of thought, so that the "mind's eye" may receive the impression; and memory recognizes the former perception. Conceptions are, of course, as varied as the means of perceiving; *i. e.* we may form conceptions of past impressions conveyed through any one of the senses: thus the character and readiness of conception vary much in different individuals, according to the natural developement or cultivation of peculiar tastes: some have the power of summoning at pleasure the extended landscape of hill and dale, of forest and stream; and others derive equal enjoyment in recalling the varied strains of beautiful music: and even the scent of sweet flowers may be conceived, though absent; or the epicure may renew his regretted feast, by the vivid impressions made on his dainty palate. The power by which conception is collaterally aided becomes a separate faculty. Although to a certain extent improveable by proper training, this faculty will sometimes refuse to be controlled by the will, and painfully mock our efforts to enlist its magic power in tracing the features or recalling the voice of those who are or were dear to us; whilst, fickle, it will present all most vividly in dreams: thus Coleridge makes the heroine of his *Remorse* exclaim on waking:—

> "I heard a voice; but often in my dreams
> I hear that voice! and wake and try—and try
> To hear it waking! but I never could——
> And 'tis so now——even so——
> ——————'tis lost again!"

The capability of giving a lucid and vivid description of any thing that has been witnessed depends on the perfection of conception; and the morbid conditions of the same faculty give rise, in great measure, to the strange vagaries of the imagination, which come under the category of spectral illusions.

Having thus endowed the mind with the capability of *perceiving* and *attending* to an impression, as well as the further power of *recalling* that impression, the next faculty required is that of voluntarily classifying and arranging the varied perceptions or facts as they present themselves; as, e. g., the selection and combination of objects which are allied or possess certain properties in common: this faculty is called Abstraction. It is the groundwork of classification, and, as Stewart remarks, "without it we should have been per-

* See Stewart's *Elements of the Philosophy of the Human Mind*, vol. i. p. 92.



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fectly incapable of general speculation, and all our knowledge must necessarily have been confined to individuals."* The faculty of abstraction is as wide in its range as it is varied and important in its bearings and operations: it is alike subservient to the power of reasoning and to the exertions of the "creative imagination;" whilst it is the mainspring and essence, as it were, of the exact sciences, and the great principle without which inductive philosophy could not have existence. This faculty is, therefore, the offspring of experience and education. Unaided by cultivation of mind, we know how incapable the illiterate are of drawing just deductions from even limited data; and far less so where great or general inferences are involved. It is not a simple ignorance of truth, or want of facts, that is the rife source of vulgar errors and prejudices: it is the incapacity to exercise the power of abstraction: whereas, on the contrary, it was to the perfection of this generalizing faculty that we are indebted for the splendid discoveries of a Newton or a Hunter.

An interesting faculty—an unobtrusive yet all-pervading web, which is woven in among, and unbidden coerces by its gentle influence, the other faculties—next presents itself: it is the "Association of Ideas." Illustrations of this power are so familiar to all, that they scarcely need be offered. A thought, a word, the most trivial object, are all capable of lighting up the train of association by which scenes, individuals, and actions are recalled, without an effort of the will; now delighting the imagination, or feeding reflection—now soothing our sorrows, or quickening our anguish and regret for objects and pleasures long gone by. Without this faculty, language would be useless, and memory almost a void. Its acuteness is, unquestionably, very much dependent on original conformation of mind; and is usually most developed in those who are most keenly sensitive and alive to kindness or neglect: in such persons it often assumes a morbid cast, yielding nutriment to imaginary slights and wrongs; and thus, as in the case of the hypochondriac, does the gall of misinterpretation frequently embitter the cup of social or domestic peace.

Association may, however, be cultivated, not by direct ordering of the will, but by attention to the proper regulation of those objects or thoughts which we allow to be habitually presented to our conception. Thus, familiarity with the world, and an accurate observation of mankind, tend essentially to the cultivation of this faculty, in exhibiting to us the characters of others: a word or look will often unfold to the acute observer much of the secret thoughts and character of an individual; and this result is solely dependent upon the capability possessed by the observer of associating that which is apparent with that which is hidden—in fact, as Stewart remarks, of making the thoughts and feelings of the speaker his own. This faculty is in constant and untiring operation: we never cease to think, and association never ceases to supply the links which connect our thoughts;—nay, during sleep we have little reason to doubt that ideas are still presented in continuous succession, although memory only sometimes supplies us with the dream.

This leads, by a natural transition, to the consideration of that voluntary faculty by which perceptions are recalled at pleasure; it is Recollection. This term must not be confused with memory: the latter is the simple negative faculty—the former is active and under control of the will. Thus the common expressions "to try to recollect something," conveys a very different meaning from such another as, "my memory does not serve me:" we are conscious of the *existence* of the one, of the *operation* of the other faculty. It is, then, by our voluntary direction of "recollection" that we obtain considerable influence over the train of associated thought. We may dismiss one set of ideas by calling up some fresh and individual object of conception; and thence will flow a ready and natural stream, tending to invigorate or degrade the moral and intellectual powers, according to the natural constitution of the mind and habitual regulation of the objects of thought.

The present seems a fitting opportunity for introducing a passing observation on the *indelibility of impressions.* If the proximate connection between the sensorium and external impressions be a mystery to us, (and there can be no doubt it is,) then it is vain to extend our inquiry to the question, involving the nature and immediate cause of the *permanency* of such impressions. We must be content to investigate the simple fact as it stands, without regard to the relative proportion of a finite organ and the infinitude of impressions it appears capable of receiving and retaining. We are apt to interpret the capacity of the mind for facts by the ability to recall that which has been presented to it; or, in other words, to employ the term Memory to express that capacity. Such is the sense in which that word is usually employed by writers on Mental Philosophy, and, for all practical purposes, it is sufficiently correct: thus, by saying that one person has a better memory than another, we mean that his mind is capable of retaining a greater number of impressions. If, however, our object be to define critically what is meant by Memory, probably some qualification will be found essential: of this, however, presently. It seems very reasonable, though truly wonderful, to suppose that an impression once made on the brain is indelibly stamped there,—is never erased. This speculation it would be, of course, impossible to prove to demonstration; but a careful observation of our own minds, and analogical reasoning founded on some remarkable instances which are well authenticated, would tend to support the conjecture. We are all conscious of the power of Association, in recalling an impression which has been dormant for months, perhaps for years, and which probably never would have presented itself unless summoned by the magic spell of some remarkable event with which it was connected. How often do such associated circumstances rise to the surface of the mind but for a moment, again to sink and be lost for ever; or dart across the horizon of our conception, so rapidly as to leave but an imperfect track of light, which we vainly pursue, striving to recall by the aid of association that reality which seemed to have presented itself but to mock the efforts of recollection! *

The definition of Memory, in the qualified acceptation above alluded to, may be thus given: it is

* *Opus cit.* vol. i. p. 155. See also the opening of Adam Smith's Essay on the *Origin and Formation of Language*, appended to his *Theory of Moral Sentiments*, vol. ii. p. 343.

* The reader may turn to Dr. Abercrombie's work on the *Intellectual Faculties*, ch. on *Somnambulism*, for some striking instances illustrative of the above remarks; see also Article SOMNAMBULISM.

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the capacity of preserving *knowledge*, or, in other words, of retaining facts which may be rendered available by the employment of the *active* faculty. Thus, it is to be distinguished from that property of the mind which involves the simple permanency of impressions on the one hand, and on the other from the active faculty Recollection, by which impressions are voluntarily recalled. Memory may have relation to tangible objects or to events; but, in either case, it is intimately linked with other faculties: thus, *conception* embodies an object which *memory* recalls; and *association* lends its powerful aid in leading the latter faculty through the intricate mazes which conduct to the desired event.* But, for its accuracy and improvement, memory is most dependent upon *attention*: through the active exercise of this last faculty alone can the capacity of memory be enlarged: and it behoves those who seek such improvement, to cultivate most diligently a *habit* of commanding and fixing the attention; which involves little short of giving the whole powers and energies of the mind to the existing subject of employment.

The difficulty of treating Imagination as an independent faculty is caused principally by the close analogy it bears to *conception*. Probably Stewart's distinction is that which is most consistent with truth, viz. "that it is the province of conception to present us with an exact transcript of what we have formerly felt and perceived; whilst that of imagination is to make a selection of qualities and of circumstances from a variety of different objects, and by combining and disposing these, to form a new creation of its own."† It has already been remarked that conception employs *all* of the senses as media by which it is enabled to select objects for embodying: but writers on Mental Philosophy are at issue as to whether the imagination may be allowed the same range. Thus, Addison and Reid would limit the province of Imagination to objects of sight:—the former writer remarks, "we cannot have a single image in the fancy that did not make its first entrance through the sight." In this opinion, Dr. Reid coincides; but Stewart justly combats this notion as altogether arbitrary, observing that "though the greater part of the materials which imagination combines be supplied by this sense, it is nevertheless indisputable that our other perceptive faculties also contribute occasionally their share. Thus, how many pleasing images have been borrowed from the fragrance of the fields and the melody of the groves; not to mention that sister art, whose magical influence over the human frame, it has been, in all ages, the highest boast of poetry to celebrate."‡ Imagination, however, can scarcely be treated as a simple faculty of the mind, like those already discussed: it is really constituted of a combination of several faculties, such as association of ideas, conception, abstraction, taste, &c.; to the co-operation of which the splendid productions which are ascribed to the fancy of the poet or the painter are really due. That this faculty also is very directly under the control of the will, and therefore involves responsibility in its proper regulation and employment, is attested by our own consciousness. The wise remarks which our great moralist puts into the mouth of the philosophic Imlac should be especially treasured by the young.§

* See Stewart. *Op. cit.* p. 404, *et seq.*
† *Op cit.* p. 482.
‡ *Ibid.* p. 483.
§ Johnson's *Rasselas*, ch. xliii.

Casual allusion has been already made, in a preceding part of this article, to the relation of instinct and reason; to which brief distinctive definition space will oblige us to confine ourselves.* Reason cannot be treated as a simple faculty, and therefore does not take its place in the same category with those already considered. The limitation of its meaning is not strictly defined; *i. e.*, it is variously restricted by different authors: in its most comprehensive sense, it may be said to include those characteristics by which humanity is peculiarly, though not altogether exclusively, distinguished: of these the most important and conspicuous are, "the power of devising means to accomplish ends, with the power of distinguishing truth from falsehood, and right from wrong." Such is the definition which Stewart gives,† deprecating at the same time, with his usual good sense, the foolish disputes which have arisen upon this subject, solely from verbal differences, or from "questions of arrangement and classification, of little comparative moment to the points at issue." The fundamental laws of human belief,—deductive and inductive evidence,—and, of course, the science of logic, all form a part of this vast subject.

### *Sympathetic System of Nerves.*

Lastly, the functions of the *sympathetic*, or *cyclo-ganglionic* system (as it has been not inaptly styled), remain to be considered. In the historical sketch which has been given of the progress of neurological physiology, it has been shown that this system is not a mere appendage to the cerebro-spinal, but that the two are fundamentally independent; though the extended interchange of fibres sufficiently accounts for the evident sympathy, and, to a certain extent, community of function that exists between them. In essential constitution the sympathetic does not differ from the cerebro-spinal system, being composed of ganglia or axes, and radiating and communicating fibres or nerves. The properties of these *axes* are still involved in considerable obscurity; a fact which is referable to the difficulty of obtaining evidence from observation or experiment, by reason of their diffusion and consequent multiplication: this arrangement is doubtless connected with the offices required of the system under consideration. Want of space will forbid a detailed account of the many hypotheses regarding the functions of the sympathetic ganglia: but, guided by analogy and gleaning from the scanty field of observation, an endeavour will be made to point out, as succinctly as possible, the most probable offices that may be assigned to them.

The position of the sympathetic ganglia, and distribution of their principal branches in connection with the viscera of the thorax and abdomen, naturally point to these organs as the seat of the principal functions of this system of nerves. The offices of the above viscera comprise the process of assimilation in its different stages; embracing, under the two great heads of *secretion* and *muscular motion*, the various functions which aid directly or collaterally in the conversion of the food into the circulating medium, and its subsequent distribution and conservation in a state adapted to the wants of the animal economy. It needs no argument to prove the importance of these offices being under the

* For further information the reader may consult with advantage the able article "Instinct" by Dr. Alison, in the *Cycl. of Anatomy*.
† *Op. cit.* vol. ii. p. 6.

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charge and direction of that form of nervous influence, the agency of which is essentially independent of, and therefore uncontrollable (save indirectly) by, the will. These considerations would conduct us, *à priori*, to the inference that such a system as the sympathetic is that which would be required to fulfil the above desiderata; nor are we disappointed in the conclusions which may be justly deduced from an experimental examination of the subject. Add to which, the moment of distributing, instead of concentrating, sources of nervous influence for their due preservation from injury, where the protecting parietes are not of the same resisting description as those of the brain and spinal marrow, and it may be admitted that the hypothesis which assigns to the sympathetic ganglia and its branches the same relation as subsists between the encephalic centre and its appropriate nerves, is at the least plausible.

First, of *muscular motions*, which are totally and at all times independent of the direct influence of the will. To this class belong the contraction of the heart in the chest, and the motions of the alimentary canal in the abdomen. Evidence that these organs are *fundamentally* independent of the cerebro-spinal system is obtained by the simple experiment of removing them from the body and marking the result; they continue to contract in the same rhythmical order as before their isolation; and the ultimate cessation of these motions is referable rather to loss of vitality from other causes, of which the most important is the want of blood, than to the absence of nervous influence. Contraction of voluntary muscles, after isolation, is irregular, and only extorted by the application of irritants. Further, experiments prove that mechanical, galvanic, or chemical stimuli applied to the large cœliac ganglion of the abdomen, for example, excite greater activity in the peristaltic action of the intestines; and the same effect has been observed by Müller to succeed irritation of the splanchnic nerves; whence, as well as from the continued action of the isolated heart or intestines, he infers that the influence of the *ganglia* is not necessary for the production of these phenomena;—a conclusion in which we are not prepared to coincide, for the reason already stated, viz., that the distribution of ganglia is so extended and diffused, that they probably pervade the muscular structure of the organs over which they preside, even where the eye cannot detect them. It would seem probable, though scarcely to be received as an axiom, that the muscular movements under the direction of the sympathetic ganglia are called forth in the same way as those referable to, and classed under, the excito-motory system: *i. e.*, an impression is first made on the peripheral extremities of the nervous fibres, and thence conducted to, and reflected from, the ganglia to the muscular fibre. The principal argument by which this supposition is supported, is the apparent necessity of a natural stimulus for the continuance of an active condition of the organs thus controlled; the heart, for example, requires the stimulus of distention with blood; and thus, where there are repeated and strong muscular efforts, the more rapid supply to the heart calls forth more frequent contractions of its auricles and ventricles; respiration becoming proportionably accelerated to supply a sufficiency of oxygen for the decarbonization of the blood: thus, likewise, the peristaltic motion of the intestines is more active during the presence of food. The regular rhythmical or peristaltic type of the muscular motions under the control of the sympathetic ganglia appears to be invariable: but we have no means of accounting for this peculiarity.

It is questionable whether this system is capable of communicating *sensations* to the sensorium: probably the indistinct evidence in favour of the affirmative supposition is referable to the fibrils of the cerebro-spinal system which intermingle with the cyclo-ganglionic branches. It is not improbable that the latter system may be the medium of propagating impressions to the former, by which excited movements are originated.

It has been already observed that Bichat* first attributed the office of presiding over the secreting properties of the viscera to this division of the nervous system; whence be styled it the "organic system."† Reference may be made to the work of Brachet‡ for details on this subject; he sums up the result of his numerous experiments in the following words: "The parotid glands secrete saliva after section of the facial nerve. The mucous tissues of the lungs, stomach, intestines, &c., possess the power of secretion, although cut off from the cerebral influence by the section of the eighth pair: the testicles secrete semen in the paralysed, and in animals after division of the spinal marrow; and the secretion of the urine is also under the direct influence of the sympathetic." He further adds, "the exhalations are equally under the direction of the same system."

We thus recognise in the vegetative system an important and distinct division of nerves with their appropriate and independent centres of influence. That the mutual interchange of fibres and consequent sympathy in function between it and the cerebro-spinal system are extensive, has been already pointed out: and thence we may gather an explanation of many otherwise inexplicable phenomena connected with secretion, sensation, &c.: and that from this intimate connection many interesting and important pathological lessons may be culled, those conversant with disease can testify. We have said that we *believe* the sympathetic fundamentally independent of the cerebro-spinal system for its supply of vis nervosa: we do not say that the present state of our knowledge warrants a dogmatic assertion that such is the case.

### Of the Muscular Tissue. §

*Tela Muscularis*, Lat.; *das Muskelgewebe*, Germ.; *le Tissu Musculaire*, Fr.

The purposes which the vital motions of the animal frame subserve are various, and will be found severally appended to the organs or functions which those motions are allied with or influence. The present object is, to notice briefly the different sources of vital motions, and to examine more particularly the structure and functions of muscular fibre. The latter division will comprise the following points: 1. General structure and organization of muscles. 2. Chemical and microscopical analysis of muscular fibre. 3. Its contractility. 4. Developement of the muscular system in different classes of animals. 5. Textures essential to or connected with muscles. 6. Form and nomenclature of

* *Anatomie Générale*, tome i.

† The term "Vegetative" is employed by the Germans.

‡ *Fonctions du Système Nerveux Ganglionaire, par* J. P. Brachet, 1834. See p. 264-5.

§ As much of the physiological part of the present subject has been necessarily anticipated in treating of the functions of the Nervous system, to obviate repetition the reader is referred to the preceding section.

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 muscles. 7. Their exercise; and 8. their condition after death.

The vital motions present themselves under two distinct forms, the *ciliary* and *muscular*. The *former* is performed by means of minute *cilia*, the bases of which are attached, whilst their free extremities vibrate: they are found on certain membranes in the higher animals, but their operation is more various, and connected with more important functions in the lower classes. The *latter* results from the active contraction of the tissue called *muscular fibre*, by which different points of the bony fabric are approximated, as in locomotion; or the several offices which constitute assimilation are importantly controlled. Both these forms of motion must be distinguished from a third, which is extensively employed for the purpose of economizing power, viz., *elasticity*: the organs exclusively endowed with this property are incapable of *active* contraction; their office is therefore confined to the antagonism of *direct* muscular contraction, as in the ligamentum nuchæ of many herbivorous feeders; or of *indirect*, as in the resiliency possessed by the organs of respiration and circulation.*

*Ciliary motion.*—The term *cilia* is derived from the resemblance of the minute organs which it is employed to denote, to small hairs, such as the eye-lashes. Their use is limited to the motion of fluids over the surface on which they exist, or of the locomotion of the animal possessing them in a fluid medium: hence they are only found on those membranes in the higher animals which have a fluid secretion, or on the surface of those lower animals which live in water or some other liquid medium. In the infusory animalcules, for instance, the cilia are subservient to both of the above purposes, at once supplying their possessor with the power of locomotion, and of producing currents in the surrounding fluid, by which particles of food are conveyed to the mouth, and the function of respiration is performed. The organs of ciliary motion were first accurately described by Purkinje and Valentin,† whose work contains an account of all that is at present known upon the subject. They give, as the varying length of these transparent hair-like processes, $\frac{1}{[illegible]}$th to $\frac{1}{[illegible]}$th of an English inch; and represent them as cylindrical or flattened, and generally pointed at their free extremities. Very little is yet known with certainty regarding the cause of motion in cilia: though there seems to be but little doubt that the phenomenon is referable in some instances, as in the rotiferous animalcules, to a distinct muscular power exercised at will: indeed Ehrenberg has described the muscular apparatus by which the cilia are moved in these animals. Müller seems disposed to regard other cilia, which are apparently homogeneous in structure, as a contractile tissue *sui generis*. This latter class are unaffected by the application of narcotic poisons, and continue their vibration as long as the textures to which they appertain remain undecomposed. Cilia are found in most invertebrated and all vertebrated animals: in the former they exist on both internal and external surfaces; in the latter, the following parts may be enumerated as presenting them:—the upper part of the alimentary canal in reptiles; the mucous membranes of the respiratory and uterine organs of mammalia, birds, and reptiles; the serous membrane of the ventricles of the brain in mammalia, birds, amphibia, and fishes; and likewise the pericardium and peritoneum of the frog.* 

* Other secondary forms of vital contraction exist, which are dependent principally on vascular changes, or external (as atmospheric) influence: the erectile tissues and dartos scroti are examples of these.

† *De Phenomeno Motus Vibratorii, &c.* 4to. 1835.

### *Motion of Plants.*

Before entering upon the nature and properties of muscular fibre, it will be desirable to make a few remarks on the irritability and motions of vegetables. There are certain properties common to all organized matter, whether animal or vegetable, and of these Irritability is a prominent one. This term, as ordinarily employed by botanical writers, means, according to Professor Lindley, "those extreme cases of excitability in which an organ exhibits movements altogether different from those we commonly meet with in plants." † Of this kind of irritability the above-mentioned author enumerates three distinct classes; viz., "those which depend upon atmospheric phenomena, spontaneous motions, and such as are caused by the touch of other bodies." To the first of these classes of exciting causes, the condition which Linnæus denominated the "sleep of plants" is referable: the folding of the leaflets and recurvation of the petiole as night approaches, in plants with compound leaves, and their re-expansion and elevation at return of day, are the most familiar examples of atmospheric influence. Spontaneous movements are more rare: the contortions of the filaments of oscillatorias, and movements of other confervas, illustrate this form of motion. The most remarkable instance referred to by authors is that of the *hedysarum gyrans*, "the lateral leaves of which, especially in warm weather, are in continual motion both day and night, even when the terminal leaflet is asleep." ‡ Instances of the movements which result from the contact of extraneous bodies are frequent. Of these the oft-cited case of the sensitive plant, *mimosa pudica*, presents a familiar example: its leaves are rapidly folded together when touched. So likewise the stamens of the common berberry-flower spring towards the pistil, when touched on their inside with a pointed instrument. The analogy between the vital irritability of plants and animals seems to derive considerable support from a consideration of their apparently identical susceptibility to the influence of poisonous bodies. The authority of Marcet, Macaire, Christison and Turner is quoted by Professor Lindley, to whose work we refer for details. § This author remarks, in commenting on the observations of the above experimenters, that "gases which rank as irritants in relation to animals seem to act locally on vegetables, destroying first the parts least plentifully supplied with moisture. The narcotic gases—including under that term those that act on the nervous system of animals—destroy vegetable life by attacking it throughout the whole plant at once." The experiments of Macaire gave the following results. ‖ The stem of the common berberry being placed in dilute prussic acid for four hours, the

* Further mention will be made of these organs in the description of the animals in which they are found. The reader may also consult, in addition to the work already noticed, Dr. Sharpey's article "Cilia," in the first vol. of the *Cyclopædia of Anatomy*, and Müller's *Handbuch der Physiologie*. Dr. Sharpey states that the crustacea are the only class of animals in which he has failed to detect cilia.

† *Introduction to Botany*, 1835. p. 346.

‡ *Ibid.* p. 347.

§ *Op. cit.* p. 350.

‖ *Bibliothèque Universelle*, tome xxxi. p. 244, as quoted by Lindley.

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irritability of its stamina was destroyed. A second experiment on the same plant, in which an aqueous solution of opium was employed, was attended by the same result in nine hours. Arsenic and corrosive sublimate produced the same effect accompanied by rigidity and hardness. In the mimosa again, when a cut leaf was allowed to fall upon a solution of corrosive sublimate, its contraction was rapid and permanent. In a similar experiment, where a cold dilute solution of opium was used, the leaf gradually expanded and lost its excitability after the lapse of six hours, although it retained its natural appearance. Strong prussic acid produced the same effect, but much more rapidly; and after exposure to the vapour of the same poison, ammonia seemed to aid in restoring the injured plant. For the best explanation concerning the proximate cause of these phenomina in the vegetable kingdom, the reader is referred to the writings of M. Dutrochet; viz., his *Recherches Anat. et Physiol. sur la Structure interne des Animaux et des Végétaux, et sur leur Motilité, Paris*, 1824; and his more recent *Mém. pour servir à l'Histoire Anat. et Physiol. des Végétaux et des Animaux.*

*Physical characters.*—The muscles are those parts of the frame which are commonly recognised under the title of "flesh:" they form the principal mass of the limbs, and are expanded, with varying degrees of density, over nearly the whole trunk, and a great part of the head and face. Each muscle is constituted of many bundles, which are in their turn divisible into smaller fascicles, and so on till the ultimate or primitive fibre is arrived at. The physical properties by which muscular fibre is generally characterised are, a reddish colour, soft consistence, scarcely any elasticity, but a capability before death of resisting considerable force. The presence of fibrin is the most prominent chemical characteristic. Muscles are highly organized: the amount of vascular supply being proportioned to the volume and exercise of the organ supplied. The arteries are derived, for the most part, at intervals, from the main arterial trunk to its progress towards or along the extremities; but in some instances large branches are separated, and appropriated to the supply of a region or particular set of muscles, as in the thigh: as they divide and subdivide, they are lodged in the interstices between the fleshy bundles and fascicles, until they terminate in the capillaries, where the veins commence. These latter vessels generally, but not invariably, correspond with and accompany the arteries, which they exceed in capacity. The communications (anastomoses) severally between both sets of vessels are very frequent, for obviously important purposes which will be noticed hereafter. In nerves likewise the muscles are very rich: their branches sometimes, but not invariably, accompany the vessels in their ramifications: their mode of termination has been already noticed in the preceding section.* Muscular tissue, when exposed in small portions to the influence of the air, dries, but decomposes in the mass. It may be freed from its colouring matter (like the fibrin of blood) by repeated washing in cold water: it shrinks and acquires greater density by boiling; and does not yield gelatine† by this process, as do the elastic and other contractile tissues already noticed. Lastly, its density is increased by alcohol, dilute acids, alum, common salt, nitre, &c.

* See *Nervous System, Structure, &c.*

† *i. e.*, the gelatine so procured is derived from the connecting cellular tissue.

*Chemical characters.*—The following analysis of the muscular fibre in the ox is given after Berzelius:—

| | | |
|---|---|---|
| Muscular fibre, vessels, and nerves | 15·8 | 17·70 |
| Cellular tissue (by boiling converted into gelatine) | 1·9 | |
| Soluble albumen and colouring matter | | 2·20 |
| Alcoholic extract with salts | | 1·80 |
| Watery extract with salts | | 1·05 |
| Phosphate of lime with albumen | | 0·08 |
| Water and loss | | 77·17 |
| | | 100· |

The substance "osmazome," on which the peculiar smell of meat depends, is not a simple substance, but, according to Berzelius, compounded of many.

The *ultimate* analysis of muscle yields, according to Sass and Pfaff,*

| | |
|---|---|
| Carbon | 48·30 |
| Hydrogen | 10·64 |
| Nitrogen | 15·92 |
| Oxygen | 17·64 |
| Fixed salts | 7·50 |
| | 100· |

*Microscopic characters.*—It has been already observed, that each muscle is composed of bundles, which in turn consist of secondary fascicles, these being ultimately resolvable into *primitive fibres*. The difficulty of identifying muscular fibre under all circumstances by chemical analysis only,† as well as the hope of discovering some physical peculiarity by which the muscles of organic and animal life might be distinguished, has led to a careful examination of those primitive fibres; and the results obtained by recent investigators, with the aid of our present improved microscopes, has been very satisfactory. According to the earlier inquirers into this subject, as Sir E. Home, Prevost and Dumas, and others, the primitive muscular fibrils consist of a series of globules agglutinated together; and this opinion is not yet altogether discarded. Other anatomists regard them as *simple* or *beaded* threads: it is under these two last-mentioned forms that the two different classes of muscles present themselves.

For the most part, the muscles of animal life may be distinguished from those of the organic system by their deeper colour; but this is not invariable: neither does the beaded character exclusively appertain to the voluntary, or the uniform filamentous character to the involuntary muscles: the heart is an exception in the one class, and the m. expulsor vesicæ in the other. If a delicate shred of a voluntary muscle be placed, after maceration for a short time, in the field of a good microscope, it will be found to present a series of transverse bands or striæ which traverse the muscle in a parallel direction, exhibiting usually a slightly waved appearance. Such is the character presented by the fascicle; and this results from the beaded enlargement of the primitive fibres at fixed and even intervals. The supposition that these globular swellings were identical with the nuclea of the blood particles is successfully combated by professors Wagner and Müller, on the ground that they by no means essentially agree in size. Ac

* Meckel's *Archiv.* v. 332. The above authorities are selected by Muller, in his *Physiology*.

† Allusion is made to certain *fibrous* tissues, which, however, differ from muscle in their vital properties.

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cording to Dr. Schwann, (whose accurate investigations are quoted by Professor Müller,)* the diameter of the primitive *fascicles* varies from $\frac{1}{75}$th to $\frac{1}{18}$th of an English line; and that of the beaded primitive fibril from $\frac{1}{1150}$th to $\frac{1}{1333}$th of the same measure. The interval between the striæ was found by the same anatomist to differ considerably even in neighbouring fascicles of the same muscle; the average space occupied by five being about 0·0060 of a line. The primitive fibrils of organic muscular fibre (such as pervades the whole alimentary canal, the ducts of glands, &c.) are uniform filaments of about $\frac{1}{1500}$th of an English line in diameter. They are likewise detected extensively in the invertebrate classes.†

It is well known that exercise augments the bulk of a muscle, but investigations have hitherto failed in satisfactorily demonstrating whether this increase is dependent on expansion of the original fibre, or numerical accession: the latter form is more in accordance with the general laws of growth. That the developement of the muscles in the highest class of red-blooded animals is regulated by the same progressive law as that by which most other structures are guided, is proved by the fact of their "passing through the soft, colourless, homogeneous and gelatinous condition of those of the lowest animals, before they assume the red colour, the dense fibrous structure, and the highly irritable and contractile property, which they possess in their mature form."‡ Muscle does not possess the property of reproducing its own structure: when a solution of continuity, as from injury or disease, occurs, the new texture by which union is effected appears to be condensed cellular membrane, possessing none of the characteristic vital properties of muscular fibre.

*Contractility.*—In addition to the properties already mentioned as distinguishing muscular fibre, its most prominent characteristic of *contractility* has yet to be noticed. Reference has already been made to the influence possessed and exercised by the nervous system in the production of this vital phenomenon:§ it will therefore suffice here to repeat, that muscles are supplied by two sets of nerves derived from independent sources; and, though bound up in the same sheath (under the form and appellation of a compound nerve) for convenience in distribution, the several primitive fibrils maintain throughout their whole course a perfect independence of each other, as well as distinctness of function. Those nervous fibres derived from the anterior columns of the spinal cord are devoted exclusively to the production of motion, whilst the posterior roots endow the muscle with such low sensibility as it possesses, and also form the medium of communication between it and the sensorium, by which the latter is rendered cognizant of the various conditions of the former, whether in a state of activity or rest. The dependence of muscular fibre on the presence of arterial blood for the healthy developement of its vital contractility is amply established by experiment, as indeed it is a matter of familiar observation. This influence may be mediate or direct: *i. e.*, total loss of muscular power is produced, as in fainting, by abstraction of a large quantity of blood; but here the effect is indirect, or consequent on suspension of the functions of the brain: the more direct agency of this fluid is negatively proved by the experiment or operation of placing a ligature on a large arterial trunk; the muscles supplied by it are partially or wholly paralyzed until the circulation is restored; but even in this instance, it is probable that the effect is partly referable to the arrest of supply to the muscular nerves. A further and more difficult subject of inquiry is that relating to the influence of the nerves themselves; viz., does the property of *excitability*,* evinced by muscular fibre, depend on the presence of nervous matter, or is it an independent attribute, a property *sui generis*, possessed by the muscular fibril itself? The former hypothesis is rendered the more probable by the following amongst other considerations: 1. Those agents which excite or paralyze a muscle by direct application will have a similar effect when conveyed through the medium of the nerves; and the converse is likewise true: 2. The removal, by dissection, of the nervous fibrils from a muscle as far as was practicable, has been found to destroy the susceptibility of the latter to galvanic influence: and, 3. The extinction of the natural excitability of muscles which have been long paralyzed by permanent disjunction of the supplying nerve in some part of its course; a result, however, which is probably, in part at least, due to protracted disuse of the parts so circumstanced. The *modus operandi* of nerves upon muscles is a subject concerning which (as already observed) we know nothing: for their structural relation to each other, the reader is referred to the preceding section. (See *Nervous System.*)

The actual condition of the muscular fascicle and primitive fibril during its actively contracted state has been likewise made a subject of investigation by many microscopical observers. The contraction of a muscle, by which its two extremities are approximated, is accompanied by increase of bulk and firmness of its intervening portion or belly. The surmise that actual condensation of structure is coincident with the above condition has been confirmed by the experiment of placing a portion of muscle, which still retained its susceptibility to the stimulus of galvanism, into a bottle filled with fluid, and having a fine tube affixed to its neck; the liquid was observed to descend when the galvanic current was transmitted through the muscle. It would appear, from the observations of Prevost and Dumas,† and more recently of Lauth and Müller,‡ that the shortening and increased bulk depends partly upon the angular inflexion of the muscular fascicles, which the last physiologist describes as visible to the naked eye; and in part to the contraction of the primitive fibrils, or approximation of the beaded enlargements already noticed as characterizing the muscles of animal life; a point which, though not established, may be considered as rendered probable by the occasional irregularity observed in the relation of the transverse striæ which mark the primitive fibres, and which, it has been shown, are due to the linear arrangement of the beaded swellings. Further than this, all is pure speculation; for, so far from knowing how nervous influence or other stimuli operate in producing the alterations of which we have been speaking, we are not even ac-

* *Op. cit.*

† The above account has not been encumbered by the various opinions of different authors. For further information, Muller's *Handbuch* may be consulted, as well as a paper by Mr. Skey, in the *Philos. Trans.* for 1837.

‡ Grant's *Outlines of Comparative Anatomy*, p. 129.

§ See preceding section, *Nervous System.*

* Irritability, or susceptibility to an appropriate stimulus are used synonymously with the word selected in the text.

† *Journal de Physiologie*, tome iii. p. 311.

‡ Muller's *Archiv.* 1835.



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quainted with the proximate physical causes of the phenomena in question.

It is well known that muscles cannot act continuously for any length of time: an interval of rest is required, or even a slight weight becomes insupportable, as proved by the experiment of keeping the arm in an extended position without other incumbrance than its own weight. It is not improbable that the interval of repose is required for the collection of a fresh supply of nervous energy; a conjecture which seems to gather some weight from an experiment performed by the writer for another purpose; when a limb had been amputated, of which the muscles were comparatively healthy, irritation of the divided nerve which supplies the flexor muscles produced distinct flexion of the toes: a frequent employment of this stimulus was not invariably succeeded by the same result; but after an interval of some moments' repose, it did not fail: the above remark is not, however, a necessary, although a probable, deduction from these premises. The excitability of muscles does not cease with death, but is protracted for a period varying according to circumstances dependent on general organization, cause of death, age, &c. In the more highly organized, warm-blooded animals, the susceptibility is soonest lost, rarely lasting more than an hour or two.

*Classification.*—The simplest classification of muscles is into hollow and solid: the former class are those which principally belong to organic life, such as the heart and membranous chylopoietic viscera, the function of which is to contract on, and expel or pass onwards, their contents: the latter class comprises the muscles of animal life, which act as moving powers on the passive levers which constitute the skeleton. The relation of the active and passive organs of motion is not always the same; *i. e.*, in some classes (as of the articulate) the soft parts are enclosed and protected by the hard, hollow lever; whilst in the higher animals, the lever is surrounded by the muscles.*

*Developement.*—It has been observed that the developement of the muscular system is determined by the wants and habits of the animal, and, it may be added, is proportioned to the general developement and organization of the frame. In the *Radiated* classes, the locomotive acts are principally performed by means of cilia, as in the polygastric animalcules, in which they are likewise the organs of respiration: but the distinct contortions of the whole or part of the body evince the existence of a muscular apparatus independently of cilia, although the transparency of its texture prevents its detection. In the *Articulated* classes, as might be anticipated from their generally exalted organization, the developement of the muscular system is much extended, although the muscles themselves are almost colourless and transparent, but distinct and for the most part very numerous; being adapted to the varied purposes of locomotion, prehension of food, respiration, &c. In such of the articulated classes as breathe air, the muscles, though less bulky, are more distinct and compact, as well as firmer and more irritable. In the *Mollusca* again, the muscular system is less needed in consequence of the fixed condition or sluggish movements of the animal. In those which possess the power of transferring themselves from place to place, the locomotive acts are principally performed by means of a single foot, affixed to the under surface of the animal, and supplied with a complicated muscular apparatus by which the power of performing a great variety of movements is secured to its possessor: in the bivalves a strong muscle connects the inner surface of the two valves, by which the animal is enabled to approximate them at pleasure; in these animals both respiration and nutrition are performed by the currents of water which are circulated through the mantle by the vibration of cilia.

In the *Vertebrated* classes the muscles are placed on the exterior of the levers which they are attached to and destined to move: and, with the exception of fishes, they assume a more distinctly fibrous structure and deeper hue. The extent to which the muscles in different parts of the frame are developed is necessarily governed by the habits and wants of the animal; more especially such as concern its means of subsistence and security from aggression. It need scarcely be added, that a due proportion is observed between the developement of these the active and the passive organs of locomotion, though still in subserviency to the objects above mentioned. The great bulk of the muscles, then, may be defined as a series of moving powers by which the levers, of which the skeleton is composed, are acted on and set in motion. Now the great desideratum in leverage is either increase of power or rapidity of motion; but the incompatibility of the two ends, unless by the intervention of complicated machinery, usually requires a sacrifice of the one to the more perfect accomplishment of the other. Of this we have signal examples in the muscular system generally, but more especially in the limbs, where increased velocity of motion is gained at the expense of loss of power: thus most of the muscles in these parts have their insertion near to the fulcra, and therefore at a distance from the weight to be moved: *e. g.* the enormous loss of power which the *biceps flexor cubiti* sustains from this form of attachment is amply compensated for by the rapidity with which the hand is approximated to the shoulder;—not to say anything of the deformity that most result from a different arrangement, as well as the obstruction to the free motion of the elbow-joint. Most muscles are examples of the third class of levers, viz. that in which the moving power is applied between the fulcrum and weight: this form acts at a mechanical disadvantage, more power being required to effect a given motion even than if directly applied to the object to be moved; the compensation, however, is found in the law already alluded to, that rapidity of motion is augmented in a ratio inversely of the loss of power.

*Tendon, &c.*—There are certain structures which, as collaterally aiding the active organs of motion, require a brief attention in connection with the present subject; they are, tendons, aponeuroses, fibrous sheaths, bursæ, annular ligaments, sesamoid bones. *Tendons* are usually interposed between the two extremities of muscles and the bones to which they are attached; they are occasionally found intersecting muscles partially or wholly, rendering them digastric, as in the muscle of that name, or multigastric, as in the *rectus abdominis*. Their use is to constitute a strong and compact form of attachment between the moving agent and lever, and thus to obviate the inconvenience and awkward absence of symmetry which would result from the direct attachment of the

* To prevent repetition, the reader is referred to the preceding section (*Nervous System*) for the classification of the varieties of muscular movements, as determined by the different nervous centres whence they originate and to which they are severally due.

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muscular mass to the hard parts: well-marked illustrations of this design are presented by the disposition of the muscles which move the hand and fingers; their tendons commence before they pass the wrist. The primitive texture of tendon, as seen under a strong magnifying power, is found to consist of a series of parallel waving fibres, which are extremely minute: in fact, in this respect, as in the peculiarity of its yielding gelatine by boiling, it partakes of the general characteristics of cellular membrane, of which, in common with other fibrous tissues, it is a modification. *Aponeuroses*, or *fasciæ*, are expansions of the fibrous tissue, surrounding and binding muscles together: they are strong and distinct in the fore-arm and leg, where the muscles are numerous, and where the fasciæ answer the further purpose of yielding a more extended surface of attachment, or *origin*, for the muscles. *Fibrous sheaths* are a modification of the last-named structure, adapted to the confinement of individual muscles or tendons: when closely applied around the latter, they are usually denominated *thecæ*. *Annular ligaments* are the condensed portions of the fasciæ, which more immediately enclose and bind down the tendons at the wrist and ancle: they also form the inferior attachment of the aponeuroses. *Sesamoid bones* are small, flattened, and oval bones, found deposited in the interior of some tendons, which play, pulley-like, over the surface of other bones, as in the hand and foot. *Bursæ mucosæ* are shut sacs, secreting and containing a mucilaginous fluid apparently identical, both in its nature and function, with the synovia of joints: they are usually found between the prominences of bones and muscles or tendons which play over them: similar membranes are found to line the thecæ of tendons; their developement, and even existence in some instances, seem proportioned to or dependent upon the need for them; and friction or pressure sometimes produces inflammation, accompanied by considerable distension of these bursæ, resulting from an excitement to undue action in the performance of their natural functions.

*Form and attachments*.—The *form* of muscles is adapted to their peculiar functions: thus, as already noticed, some muscles are hollow, others solid. The latter present themselves under one of two forms—either as expanded surfaces or aggregated masses; but in both instances, at least one extremity of the muscle (in most cases its insertion) is usually condensed into a smaller compass, and so rendered more compact for the convenience of attachment to the part to be acted on. Thus, the muscles of the trunk are sometimes triangular, or fan-shaped, as in the case of the *m. pectorales*; whilst in others their function requires that they should be expanded throughout their whole extent, as in the *abdominal* muscles. The arrangement of the bundles which constitute the muscles of the extremities is either rectilineal, or single or double penniform. In the *rectilineal* muscles the fibres are parallel, as in the *m. sartorius*: in the *single penniform*, they run from their origin to be inserted in regular succession into a tendon which commences at a considerable distance from its insertion, as in the muscles of the *anterior tibial* region; whilst the *double penniform* present converging or diverging fibres between the line of origin and a line which traverses the centre of the muscle, as in *m. rectus femoris*. The familiar illustration of the relation which the feathery part holds to the solid portion of a quill (whence the name is derived) will serve to exemplify the arrangement in either instance.

The muscles of animal life are generally attached by both extremities to the hard parts; there are but rare exceptions to this rule in the limbs. Occasionally one extremity of a muscle is attached to bone, and the other to fascia, as in the *m. palmaris longus* of the hand, and *m. tensor vaginæ femoris*. The purely cutaneous muscles are few in man; the *sphincter* of the mouth, and *platysma* of the neck, are instances of voluntary muscles altogether without bony attachment. The *origin* of a muscle is the more fixed extremity of its attachment; the *insertion* the more moveable: the intervening portion is called the *body* or *belly* of the muscle. In some instances the origin, in others the insertion, is divided or multiplied: the *m. triceps extensor cubiti* is an example of the former, and the muscles moving the fingers and toes, of the latter arrangement. The nomenclature of muscles is founded on no single system, but derived from various sources, such as *form, attachments, number of heads, use, position*, &c.; of which the following are examples:—*m. rhomboideus, genio-hyo-glossus, triceps, levator anguli scapulæ, pectoralis*, &c.

*Exercise*.—That a free and properly regulated exercise of the voluntary muscles is conducive, indeed essential, to a healthful performance of many important functions in the animal economy, is matter of common experience and observation. This wise provision, which serves at once as an impulse to exertion, and as a means of maintaining the physical (and through it the moral) frame in that state of equilibrium which best adapts it for active employment, is due to the stimulus which the circulating system thence receives, and which seems so essential to the proper regulation of its functions. The vast mass of blood which is constantly thrown upon the muscular system is readily and favourably acted upon by mechanical pressure during exercise, (an end which is particularly provided for without interference with the natural course of this fluid,) and thus the due equilibrium between the secreting, depositing, and absorbing vessels is preserved; and the abnormal deposit of fat, or some less harmless means by which nature struggles to keep pace with or subdue the overcharged condition of the vascular system, is obviated. Where great muscular exertions are made, the augmented rapidity of circulation calls for a proportionably increased frequency of respiration, and the vessels of the skin act more freely: the explanation of these phenomena is very simple; the presence of blood in the lungs is the natural stimulus to the inspiratory effort, and of course as the general circulation is hurried, so the lungs become more frequently distended, and the requisite amount of oxygen is obtained by the more frequent repetition of respiration. In the ready determination of blood to the surface of the body during exercise, and the consequent increase of the cutaneous secretion, we recognise a wise provision against the evil results which would ensue, were the relief otherwise obtained at the expense of serious derangement of internal organs.

When life is extinct, the muscles become for a time rigid, and again relax as decomposition advances. Experiments would seem to prove that this stiffness is dependent on the coagulation of the blood in the smaller vessels and capillary system. A slight contraction accompanies this process which commences at different periods after death, varying according to the amount of previous exhaustion and natural irritability of the muscles; those of the neck and jaw are usually the first



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Zoology. to become rigid, and the lower extremities are the last affected: in the same order flaccidity is restored by decomposition. Rigidity rapidly ensues after death from protracted disease, and the converse likewise holds good, viz.: that after sudden death this phenomenon is delayed, but lasts for a longer period. Hunter and others have asserted that rigidity of the muscles does not succeed death from electric fluid.

### Of the Vascular Tissue.

*Tela vasorum communis*, Lat.; *das Gewebe der allgemeinen Gefässhaut*, Germ.; *le Tissu Vasculaire*, Fr.

Before entering on the consideration of this subject, it is necessary to observe, that different writers have applied the term *vascular tissue* to very different structures, at the same time restricting it to the blood-vessels.

Haller, in his description of the structure of arteries, does not mention any membrane or tissue as peculiar to them; he says, that "an artery is a tube made up of several membranous concentric cylinders in form of tunics;" of these, the outer is *cellular*, consisting of an exterior loose and an interior closer layer, which immediately encloses the *muscular*, composed of layers of circular fibres, connected by a very small quantity of cellular structure, and previously called by Monro the *principal coat* of arteries. These muscular fibres vary in quantity on different parts of the arterial canals, being most distinct from their quantity and redness upon the aorta, gradually become more sparing upon the smaller vessels, and on the capillaries not even to be seen with a magnifying glass. Connected with the muscular coat by a very short cellular tissue is the *innermost* coat, smooth, uniform, delicate, called by the old writers the *araneous*, and by the moderns of his own time the *nervous* coat, and according to his (Haller's) view, preventing aneurisms by passing over the non-continuous fleshy fibres and not allowing gaps between them. In adverting to one of the terminations of the arteries, viz. in veins, he mentions the opinions of the school of Erisistratus, that between them is interposed a sort of sponge, παρεγχυμα, as it was called, which notion was entertained till refuted by the microscopic observations of Malpighi, who in his second epistle, *De Pulmonibus*, published about 1661, showed the continuity of the arteries into the veins on the urinary bladder of a toad. This observation is here noticed, because, within the last few years, a very similar opinion has been advanced by Wedemeyer, who speaks of the blood in the most minute capillary vessels as no longer flowing in *actual vessels*, but in simple grooves or canals formed by the surrounding cellular tissue. As to the veins, Haller says, that the external cellular coat is delicate, that in the so-called muscular coat there are no circular fibres, and that the few fibres seen are longitudinal, but that the innermost coat pretty nearly resembles that of the arteries, setting aside the numerous valves into which in the veins it is folded.*

In the Absorbent vessels, or Lymphatics, as he calls them, Haller observes, that the structure "is the same as in the red veins. The membrane is delicate even in the larger trunks and in the thoracic duct. No fibres can be observed in them by the unassisted eye, but with the aid of glasses two layers and fibres can be seen, which were depicted by Nuckius" in his *Adenographia*.†

From this brief account it is apparent, although

* See Haller, vol. i. book ii. sec. 2. † *Ibid.* sec. 3.

Haller does not direct the attention specially to it, that in all three kinds of vessels the innermost coat is always found, is more alike in all, and may therefore not improperly be considered as the *essential* part of the vascular system. Zoology.

The next important authority on the structure of vessels, Mr. Hunter, adverts but very slightly to the innermost coat of Haller. Having mentioned the muscular and elastic powers, which he considers as "probably introduced into the vascular system of all animals, the parts themselves being composed," he says, "of substances of this description, together with a *fine inner membrane*, which I believe to be but little elastic, and this membrane is more apparent in the larger than in the smaller ramifications."* As to the two coats he particularly describes, he observes, "The greatest part of the arterial system evidently appears to be composed of two substances, which structure is most remarkable in the middle-sized arteries, where the two substances are more equally divided, and where the size admits of a visible distinction of parts." And a little further on he observes, "The internal part, which is darker but with a degree of transparency, begins almost insensibly in the larger vessels, and increases proportionably in thickness as the arteries divide, and of course become smaller; while the external, being of a white colour, gradually diminishes but in a greater degree, according to the diminution of size in the artery and of the increased thickness of the other coat; so that the two do not bear the same proportion to each other in the small arteries as in the larger."†

As to the coats of veins, Mr. Hunter observes, that "they are similar to the arteries in their structure, being composed of an elastic and muscular substance; the elastic in some degree preserving a middle state, although not so perfectly as in the arteries."‡

Upon the structure of the absorbent vessels he does not make any observation.

From an examination of Mr. Hunter's opinions, it does not appear that he considered any tissue specially belonging to vessels. The two substances he describes are not equally distributed in the arterial walls, for whilst the larger vessels are composed almost entirely of elastic substance, he observes, "as they recede from the heart towards the extremities, the muscular power is gradually increased and the elastic diminished. Hence I imagine," says he, "there may exist a size of vessels totally devoid of elasticity; but this I should conceive to be in the very extremities only," or the capillary vessels, "which appear to be almost entirely muscular."

Bichat describes also a third or common coat in blood-vessels. He divides these vessels into those conveying red and those carrying black blood, that is, into arteries and veins, the former of which are lined with a continuous membrane commencing in the capillary or most minute branches of the pulmonary veins, lines the left side of the heart, and is thence continued on the interior of the arteries; this he calls the *membrane commune du système à sang rouge;* whilst the lining of the capillary branches of the veins of the body continued along the whole of the venous trunks within the right side of the heart and the interior of the pulmonary artery, he calls the *membrane commune du système à sang noir.* Upon the exterior of this

* See Hunter, p. 117. † *Ibid. Op. cit.* p. 118.
‡ *Ibid.* p. 181.

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membrane, which is generally correspondent, though in some respects different, is placed "a membrane dense, close, very distinct on the large arteries, but less so upon their ultimate divisions, where it is insensibly lost."* This he calls the *membrane propre des Artères*, and says, that it is yellowish, but, under some circumstances, assumes a greyish appearance; that in the large trunks its thickness is very decided, and that it is arranged in circular fibres. The *membrane propre aux Veines* presents itself upon the trunks of the large veins as "longitudinal fibres, all parallel with each other, forming an exceedingly delicate layer often difficult to be perceived at the first glance, but always having an actual existence."† Both arteries and veins, according to the same writer, are invested with an external covering of tissue which he divides into two layers, a close one immediately investing the proper membrane, not entering in the arteries into the interstices of that membrane, whilst on the contrary, on the veins it dips between the longitudinal fibres, ensheaths them, and is ultimately lost in the common lining membrane, thus forming a very distinct and striking character, by which they are distinguished from the arteries.‡ From this short description, it is clear that Bichat considers the middle of these three coats to be the *true vascular tissue* of both kinds of blood-vessels, and the same view of the subject is taken by Craigie in his *General Anatomy*.

Beclard speaks of vessels as made up of three distinct coats. 1. The inner of which, delicate, whitish, more or less transparent, of uniform texture, and without apparent fibres, is continued throughout, but differs in the arteries and veins, and has great resemblance to serous membranes. 2. The outer, of a fibrocellular texture, generally formed of oblique fibres running in the course of the vessel and interlacing with one another. 3. Between the two just mentioned, exists another, formed of a peculiar fibre called the *elastic fibre*, opaque, yellowish, white, dull, dry, tough, disposed in bundles always parallel, with little obliquity, never interlacing nor connected by cellular tissue, and very easily separable. In the greater number of its anatomical and physical characters, it differs entirely from tendinous or fibrous tissue, and also from muscular tissue, with which it has been improperly confused. It resembles muscular tissue, however, in some respects, and appears intermediate between it and the cellular and fibrous. Beclard's opinions therefore upon this subject seem nearly the same as those of Bichat, but he considers the middle coat to consist of elastic tissue, which is not peculiar to vessels, as it is found in other parts of the body and will hereafter be considered.§ He does not however speak of any special vascular tissue, though it must be inferred that the inner coat is held by him to be that most strictly vascular, as, when treating of the capillary vessels, he observes, "they (the capillaries) seem rather hollowed out in the substance of the organs than furnished with proper walls. It is very probable, however, that the *internal membrane* of the vessels is continued without interruption from the arteries into the veins."‖

By the German anatomists, the innermost of the three coats, already described by Bichat, is considered "the most essential, for," says Meckel, "it is found throughout the whole extent of the vascular system, and passes from one principal part of it to another in unbroken connection."* This then is the true *general vascular tissue*, which lines the heart and the several kinds of sanguineous and absorbent vessels, and to which the surrounding coats or tunics are merely auxiliary and not essential parts in the composition of a vessel.

*Anatomical characters*.—The vascular tissue is very thin, whitish, more or less transparent, homogeneous, exhibiting neither globules, fibres, nor cells, neither pores nor interspaces, discoverable even with the assistance of the microscope. It therefore has great resemblance to serous membranes, as a species of which it is considered by De Blainville, who calls it *le tissu kysteux angéial*, and further observes, that "it is one of the elements of the circulating apparatus, indeed even its fundamental element, without absolutely constituting it."† Internally it is smooth and highly polished, so as to offer as little obstruction as possible to the current of fluids passing through the tubes which it composes. It is very firmly connected with the neighbouring tissue, and therefore cannot be detached in large pieces, either by immersion in hot water, by boiling, or by putrefaction. Albinus and Alexander Monro, however, affirm that it can be separated from the middle coat by long-continued immersion in water frequently changed. Bichat says, that its "external surface, slightly connected with the other membrane, as already seen, has no intermediate cellular tissue. In spite of this trifling connection, however, neither boiling, maceration, nor putrefaction can produce the detachment of the one or other membrane, as can be effected with periosteum and bone, which are naturally much more closely connected; recourse, must always be had to dissection."‡ It varies considerably in density in the arteries, veins, and absorbent vessels, being thickest in the former and thinnest in the latter, but it varies also in this respect in the several parts even of the same system. It is more compact, less extensible, and more frangible in the arteries than in the veins, and still more extensible in the absorbents. In the arteries, the vascular tissue forms a series of smooth tubes uninterrupted by irregularities throughout, except in the aorta immediately after its origin from the heart, at which part it doubles and forms three valves, which prevent the blood dropping back from that vessel into the heart during the relaxation of the left ventricle of that organ. In the whole venous and absorbent systems, on the contrary, it forms numerous doublings, by which sets of valves are formed to shorten the columns of fluid contained in those vessels and diminish their weight. This tissue is said to possess neither nerves nor arteries, and Wedemeyer observes, that, in the large arteries, it is inconsiderable in direct proportion to their diameter and their proximity to the heart.

*Microscopic characters*.—Milne Edward states that, with the microscope, he has observed vascular tissue to be composed of rows of extremely small transparent globules, $\frac{1}{300}$th millimetre, or $\frac{1}{1125}$th of a Paris inch in size. And Mascagni says that, under the microscope, he has seen this tissue composed of wreathing lines, which he considers to be lymphatic vessels. Both these statements are considered by Weber to be mere optical illusions; and it may be doubted, whether De Blainville is more correct, when he speaks of the "serpentine disposition of the

* See Bichat, *Op. cit.* p. 278. † *Ibid.* p. 399.
‡ *Ibid.* p. 411. § See Beclard, p. 323. ‖ *Ibid.* p. 336.

* See Meckel, *loc. cit.* vol. i. p. 151.
† See De Blainville, *loc. cit.* vol. ii. p. 280.
‡ See Bichat, *loc. cit.* p. 291.

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Zoology. arterial vascular tissue, a character proper to every fibrous and elastic tissue,"* but which, he says, does not exist in the veins; for, as this middle coat, which immediately envelopes the vascular tissue, is fibrous, and disposed obliquely in the arteries, it is not improbable that he had not completely separated the one from the other; whilst in regard to the vascular tissue of veins, in which he says "it is impossible to recognise the serpentine form, and that only a cellular and merely vascular membrane can be found," it is easily accounted for by the fibrous tissue being so thin as easily to be overlooked, by its fibres having less connection with each other, and further, by their not being generally distributed on all parts of the venous system, as Meckel has observed.†

*Chemical characters.*—In consequence of the impossibility of separating the vascular tissue in sufficient quantity, no chemical analysis has hitherto been made of this tissue. It does not, however, yield gelatine by boiling, nor does it putrefy but with difficulty. Bichat considers, that as it is acted upon by chemical solvents, just as the yellow tissue of the arteries, it has also the same chemical condition as those fibres.

*Disposition into vessels.*—The tubes by which the blood, or other similar juices, are conveyed through all the structures of the body are formed of the vascular tissue, and are called *vessels*, from performing that office; to those which distribute the blood, for the purpose of secretion or excretion, the term *artery* is applied; whilst others, which re-collect the residue which has not been discharged from the body by either of those functions, and bring it back to the respiratory organs, are called *veins;* a third kind also exists, which are called *absorbent vessels*, from conveying not merely the nutritious part of the food into the sanguineous circulation, but also because they remove from the body itself such parts of the solids or fluids as have served their purpose in the animal economy, and carry them to the blood, from which they are in various ways discharged out of the organism. The circulation, as performed by the arteries and veins, is divided into that which is especially connected with the respiratory process or exposure of the blood to the action of the air, and that by which the blood, purified by such exposure, is distributed throughout the body at large, to sustain the several vital actions performed by its numerous organs; the former is called the *respiratory*, and the latter the *general* circulation, and to each belong both arteries and veins. In the neighbourhood of the heart, which exists in all the vertebrate classes except fishes, these vessels are of large size, and in fishes they are also of large size in the neighbourhood of the gills; but in proportion as they recede from either of those organs, they branch out and become smaller and smaller, like the roots and branches of trees, till they ultimately become so small, that, from their size resembling hairs, they are called *capillaries*, or *capillary vessels*. So far as the vascular tissue is concerned, they differ in the venous branches being largely supplied with valves, *i. e.* doublings of the vascular tissue, which, as the blood flows through them, allow its passage by falling against the side of the tube; but, when once passed, prevents its relapse by dropping into the area of the vessel, and cutting it off from that part of the vessel which is below. The arteries, however, present valves, but only a single set, as the origin of each great vessel from the heart. Other distinctions as to structure exist between the arteries and veins, with reference to additional coats or tunics not composed of vascular tissue, but of cellular, muscular, and elastic tissue, which are spoken of under those heads; but it may be here noted, that in consequence of such structure, not only the large trunks, but even a very considerable part of the ramifications of arteries preserve their tubular form, whilst the corresponding trunks and branches of veins collapse, and do not exhibit that appearance. The absorbent vessels, in many respects, resemble veins, being largely furnished with valves, but they are so transparent that the colour of their fluid contents is distinctly seen through their coats; they always terminate in the venous system, emptying themselves into the blood, which is proceeding to the respiratory organs for aeration. Zoology.

*Termination of the minute ramifications of vessels.*—The termination of the several divisions of the vascular system, either by gradual transition into each other, or in an intermediate spongy or parenchymatous structure, receiving one and giving origin to another set of vessels, has afforded ample dispute among physiologists. There is no doubt that in many instances the blood passes directly from the artery into the vein, the latter, if it may be so expressed, seeming to be merely an arterial branch retroverted, and assuming one of the principal venous functions, that of returning the blood to the heart. This is a fact which can be readily and distinctly seen by placing the tail of a small fish or the webbed foot of a frog in the field of a microscope: and it can also be proved by the injection of even so coarse a material as wax from the one set of vessels to the other. But of late, the ancient opinion of an intermediate parenchyma, or of something tantamount to it, has been readvanced by Wedemeyer. Admitting the frequent direct termination of the arteries in the veins, he observes, "The greater part of this immediate passage, anastomosis, between arteries and veins, consists not however of actual membranous vessels, for the latter becoming gradually more delicate, insensibly subside into the mucous (cellular) tissue, and vanish from the sight. The flowing blood has now no longer any actual membranous vessel, it forms only streamlets, which clear themselves away in the mucous (cellular) tissue, like rivulets in the loose earth, and the canals or walls of which consist only of the general mucous (cellular) tissue, the loose cellular substance from which originally all vascular membranes are formed."* To this condition of the structure of the capillaries he had previously adverted when, in speaking of the extreme ramifications of the arteries, he says, "their innermost coat, which, like serous membranes, consists of cellular tissue, gradually diminishes in the same proportion (as their ramification becomes minute) and at last subsides, together with the middle coat, in the little vessel-less streams or canals, *in den gefässlosen Blutströmchen (canalschen)*, into a simple cellular tissue. The blood flows no longer in the most minute capillaries, nor within actual canals, the walls of which are formed by a membranous substance differing from the surrounding cellular tissue in texture and density, but within *mere grooves or canals*, whose walls are made up of the surrounding mucous or cellular tissue."†

* See De Blainville, *Op. cit.* vol. ii. p. 282.
† See Meckel, *Op. cit.* vol. i. p. 203.

* See Wedemeyer, *Untersuchungen über den Kreislauf des Bluts*, &c. p. 261.
† Wedemeyer, p. 257.

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*Vital Properties.*—The vascular tissue possesses a certain degree of elasticity which admits the enlargement of the area of the vessels, and allows the retention of a larger quantity of their proper fluids at one time than another; but after having suffered a certain extension, the tissue tears, and in the human subject a disease in the arteries called aneurism is produced. On the contrary, it is capable of accommodating itself to the diminished size of the vessels, when the quantity of their contained fluids is, from whatever cause, less than usual. Mr. Hunter states that, under contraction of an artery dependent on the emptying of its blood, its "inner surface forms wrinkles, which are principally longitudinal," but this does not appear to be always the case. The diminution of the size of the vessel does not seem to be dependent on the vascular tissue, which, beyond a trifling degree of elasticity, is almost passive, but upon the other investments of the vessel. A most remarkable instance of the increased extension of the vascular tissue periodically is observed in the great enlargement of the carotid arteries of the horns of deer during their annual growth; but so soon as the growth is perfected, and the secreting power of the arteries no longer called into action, the vessels revert to their original smaller size. The same occurs also in the uterus during gestation, and after delivery. And even in crying, where the secretion of tears has been large, the vessels of the mucous coat are readily perceived, from the unnatural redness of the white of the eyes, to have acquired increase of size, as the vessels which previously were impervious to the red globules of the blood allow their free entrance. The subject, however, will be further inquired into in considering Elastic Tissue.

As to *Difference* of the vascular tissue in the different classes of animals, it is almost, if not entirely, impossible to determine whether it exists.

*Use.*—The use of the tissue is the formation of vessels to restrain the moving fluids within their proper boundaries, a purpose which it fully effects during life; but very soon after dissolution the tissue undergoes a change, which allows their escape, and hence arises the colour which the tube assumes, corresponding to that of the fluid it contains. Some anatomists also consider that the tissue secretes a peculiar fluid which spreads over its surface and protects it from the action of the blood or other fluid contained: analogy certainly tends to support such opinion, but it does not seem to admit of actual proof.

The following tissues are composed not only of the cellular, nervous, and muscular, at least that part of the latter which most probably, though disputed, exists in the small branches of arteries, but also of other inorganic materials evolved by the arteries from the blood, and giving to these tissues their peculiar characters and properties.

### Of the Dermal Tissue.

*Tela Corii*, Lat.; *das Gewebe der Lederhaut*, Germ.; *le Tissue Dermeux*, Fr.

The Dermal Tissue closely resembles the cellular, of which indeed it is but a slight modification. It forms a case or covering, varying in density in different classes of animals, and containing within it all the structures of the body, excepting those parts which are its own products and appendages, viz. horn, in all its varieties of skin, scale, feather, hair, &c., and the bony or calcareous shells of many animals.

The terms *hide* and *skin* are commonly and indifferently, but improperly, used as synonymous of the dermal tissue, for they truly indicate two very distinct substances, the former of which, the hide, produces or secretes the latter or skin, and these together, in anatomical language, were formerly called the *common integument*. As therefore the dermal tissue is the essential part of the animal covering, and the description of the latter is completely involved in that of the former, it will be most convenient to consider them together under the present head, restricting the term hide to the generating tissue, and that of skin to the substance produced by and overspreading it; the former being a permanently existing structure, whilst the latter is continually wearing away, falling off, and reproduced; and can, together with scales, feathers, hairs, &c. without difficulty be removed by scalding or putrefaction, and leave exposed

### The Hide or True Skin.

*Corion, Derma, Cutis vera*, Lat.; *der Lederhaut*, Germ.; *le Cuir*, Fr.

When the skin has been removed by blistering the surface of a living animal, the hide is exposed semi-transparent and of a bright red colour, dependent on its great vascularity; but if the skin be disengaged after death by putrefaction, the hide is pale and white, its vessels having emptied themselves of the blood contained within them during life.

*Anatomical characters.*—Upon the external surface of the greater part of the hide are seen numerous elevated delicate lines or ridges, separated by equally delicate grooves, which are best observed as being most fully developed upon the palm or surface of the hand and fingers, and on the plantar or sole surface of the foot and toes in the human subject. The lines are longitudinal, transverse, or oblique, either straight or curved, and cross each other so as to form a beautiful but irregular network: this disposition is common to the palms and soles, and to those surfaces of the fingers and toes, except upon the cushion-like ends of those organs, where the lines are arranged in oval whirls. The grooves on these parts have a corresponding or parallel course, but upon the back of the hand especially they assume a radiated form, striking out as from a centre from the aperture through which each hair shoots, and running from one to another produce a net-like appearance, which, if examined with a microscope, is found similarly, but still more minutely, divided. At the flexures of the joints, both before and behind, the furrows are transverse, nearly straight in front, but curved or wavy at back, where their concavities face each other.

The ridges consist of series of little eminences, *papillæ corii*, which probably exist over the whole surface of the body, as they are intimately connected with the sense of touch, but are on some parts so little developed, that their existence has been denied, as for instance on the scalp; whilst on the contrary they are more numerous and distinct on those parts of the body which are more particularly ordained for that function, as exemplified in the palms of the hands and soles of the feet, and specially on the cushions of the fingers and toes. Upon these parts, each ridge is found to contain two rows of papillæ, which on the hand have a flattened rounded form, but upon the feet are more conical. The papillæ

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are very distinct upon the tongue, but without regularity; upon the lips they are also very numerous, and when distended with injection, give their surface the appearance of the pile of velvet; they are also in great numbers on the nipples, and other of the more sensitive parts of the body. These papillæ were discovered by Malpighi upon the surface of the tongue of the ox, sheep and man, subsequently also upon the toes of swine, and on the human hand; as to those on the tongue, he observes, that in substance and shape they resemble the projectile and moving horns of snails, and that they arise from the nervous and papillary body.* It is however incorrect to say that he has described this body as a distinct layer of the hide, as stated by some writers; when he first mentions it he only speaks of its two surfaces, "*hoc interiori superficie qua nectitur subjectis linguæ carnibus, &c.*" and "*exteriori verò parte inæquale est, papillas enim, &c.*;"† and he is still more explicit in the following letter, and says, that it is only the hide "*quod alias papillare placuit appellare corpus, cum revera sit cutis seu vulgatum in brutis corium, commune totius corporis integumentum.*"‡ Hintze considered the papillæ to be made up of a peculiar tissue, his *textus papilloris*. It would seem, however, that the difference between this the external surface or layer, and the under layer of the hide, or so called corion, is not very great; for though Gurlt states that "the two layers differ somewhat from each other in texture," yet the difference is merely that "in the tactile papillæ (another name applied to them in relation to their function) the tissue is very homogeneous, that is, without any network of fibrous tissue; the true hide, on the contrary, is made up of a sort of network of connected bundles of fibrous tissue, in the interspaces of which is an homogeneous tissue, probably cellular."§ Breschet considers that the form of the papillæ depends on that of the extreme branches of the nerves of touch; and knowing that the optic nerve having penetrated the eye-ball loses its neurilema, he believes that the tactile nerves, as they enter the hide, lose their proper covering, which is replaced "by the external membrane of the hide, white, and seemingly fibrous;"‖ and this appears to be the most simple and satisfactory mode of explaining their formation.

By its internal or under surface the hide is connected to the subjacent cellular tissue, and the subsidence of one into the other is so gradual as to render it almost impossible to determine where the one tissue ceases and the other commences. It is less dense and close internally than externally, and exhibits linear projections of its looser texture, which cross each other in a net-like form, leaving between them conical apertures of various sizes, which are very large on the back and belly, in the palms of the hands and soles of the feet; are of smaller size on the neck, chest, and face, but upon the backs of the hands and feet, the forehead, scrotum, and labia, are scarcely visible. They are directed obliquely from within to without, and are perforated by very minute apertures, through which vessels, nerves, hairs, &c. pass to the surface. The larger cavities are filled with fat, which, however, is not found in the smaller ones, but in all the vessels ramify minutely prior to their ultimate distribution.

The thickness of the hide varies considerably not only in different orders of animals, but in different parts of the same animal; where is most pressure, there is it thickest, as upon the palms of the hands, upon the soles and under surface of the toes, and also upon the back of the trunk in the higher classes of animals; but upon the eyelids, face, the whole abdominal surface, and the insides and flexures of the limbs, it is generally thinner than elsewhere.

The hide is very freely supplied with blood-vessels, the minute distribution of which has been described by Prochaska. When injected, its inner surface, where resting upon the cellular tissue, does not appear very red, on account of the quantity of cellular fibres and plates which are not vascular intermingled with it: if, however, it be dried, and thus rendered transparent, it becomes red, and here and there a large vessel may be seen, which forms a minute network upon the adipose cells, and thence proceeds into the substance of the hide itself, whither the vascular net also extends. The external surface, however, whether fresh or dry, is always very red, even in the living subject, which depends upon the most minute of the just mentioned reticular branches ascending to the papillæ, from which they afterwards descend and return to the network in the substance of the hide. This distribution of the vessels in the network is of the kind called by Berres *plexus arteriosus moculosus*, from enclosing little spots or places, whilst that upon the papillæ resembling a loop form his *plexus arteriosus ansatus*. Weber examined a preparation of the vascular net of the hide of the arm in a preparation of Lieberkuhn's belonging to the Berlin Museum, and found the meshes quadrangular, and the mean diameter of the vessels themselves $\frac{1}{1}{}_{\frac{1}{7}\frac{1}{7}}$ of a Paris inch.* This vascular net, which is situated in the most superficial part of the hide, is not however to be considered a part of the so-called mucous body, as stated by Gualtier, which will be presently noticed.

Lymphatic absorbent vessels are very numerous in the hide, as might be presumed from the readiness with which various substances rubbed upon the skin are taken into the system. Haase was supposed to have injected them, having pressed with a knife through the external pores of the skin mercury, which had been previously injected into the subcutaneous absorbents. Breschet, however, considers that he did not inject them, but burst the subcutaneous absorbents, and discharged the mercury by the sudoriferous ducts. E. A. Lauth,† however, has been more successful; and Breschet gives a short account of his discovery, which occurred in injecting the absorbent vessels of a dropsical patient. He filled with mercury the lymphatic ganglions of the right side of the groin, from which proceeded ganglions and branches of communication with the absorbent vessels of the penis, and other anastomotic vessels passed across immediately beneath the skin of the groin, &c. Many branches were filled by a retrograde course in the skin of the groin, and on that of the upper and inner part of the left thigh, and where these ramified in the very tissue of the skin (hide) itself, were first seen greyish

* See his *Opera Omnia*, vol. ii. p. 15.
† Ibid. *loc. cit.*
‡ Ibid. p. 23.
§ See Gurlt, *Vergleichende Untersuchungen über die Haut des Menschen und der Haus-Säugethiere, &c.*, in Muller's *Archiv. für Anatomie, &c.* 1835, p. 407.
‖ See Breschet, *Nouvelles Recherches sur la Structure de la Peau*, 1834, p. 16

* See Weber, p. 412.
† See his *Essai sur les Vaisseaux Lymphatiques*. 1824.

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Zoology. spots, which carefully examined were found to be merely plexuses of lymphatic vessels of extreme delicacy. When the epidermis (skin) was removed by maceration, the lymphatics were exposed in such numbers, that the point of a needle could not be inserted without wounding one or other of them.*

The nerves of the hide are extremely numerous, indeed that structure is most richly supplied with them, of which Breschet has given a very interesting description.† From their minute size they cannot be traced unless observed previously to their entrance into the vascular network; but if attention be paid to this point, they can be followed to their distribution in the papillæ. Breschet examined them in the whale, dolphin, and porpoise, as well as in man. He found that, although two or three might have a common root, yet that each was contained in a proper sheath; that before entering the hide they resembled other nervous branches from the spinal cord, but that in its substance they became soft, tortuous, and capillary; and that on its external surface they were transformed into symmetric papillæ, to which he applies the general term *Appareil Neurothèle*. He states, in reference to the query, Do the nerves, on their entrance into the hide, lose their neurilema? that though he cannot assert, yet he believes they do; that probably it gradually subsides as they pass through the hide, where they are sufficiently protected; "this is however certain," says he, "the external membrane of the hide, white and as it were fibrous, covers the nervous papillary substance which probably had arrived there without its neurilema."‡

*Physical characters.—Colour.*—It has been already stated, that after death the hide is of a pale white or silvery colour, but that during life it is bright red. This difference arises from the quantity of red blood which traverses the tissue during life, and of which the vessels are emptied in the act of dying.

*Extensibility.*—That the hide is to a certain degree extensible, and afterward capable of returning to its natural dimensions, is proved by the increased bulk of the stomach when filled with food distending the abdominal teguments, which however revert to their ordinary condition, as the alimentary canal is gradually relieved of its contents. The extension of the hide of the neck when the crop of a bird has been filled with food, and its return to its natural condition as the food passes to the gizzard, is a familiar example of this fact. But the most remarkable instances of the extension of the tegument are afforded by the greater number of serpents, the prey of which often exceeds twice or thrice their own ordinary bulk, yet in its passage through their gullet the hide readily distends; our common snake, which will gorge a frog twice or thrice as large as itself in girth, offers a good example; but the best are the pythons and boas, the former of which are capable of swallowing goats, as witnessed by Dr. Abel,‖ and it is said even oxen. The same occurs in obesity, but whether, if emaciation follows, the hide will retract to its original size, depends principally upon the age; if the person be young it will generally do so, and there will not appear any redundancy of the tegument; but if he be advanced in years, the hide has not power to revert to its original condition, but remains hanging in loose unsightly folds. Even in childhood, in cases of severe emaciation, it occasionally happens that this pendulous state of the tegument occurs. In neither of the cases mentioned has the hide suffered any injury by the distension, but examples occur in which it is damaged by natural and healthy processes; thus during pregnancy, up to a certain time, the abdominal tegument yields without giving way, but that passed, the fibres of the hide tear again and again, and after delivery the mischief done is plainly indicated by the numerous transverse scars with which nearly the whole abdominal surface is overspread.

*Chemical characters.*—The hide does not easily become putrid, but it dries quickly and becomes semi-transparent soon after the removal of the skin. If subjected to long continued boiling, the greater part of it is converted into gelatine, which Hatchett says is more dense in consistence, and less soluble than in other cases. According to Seguin, it consists of two parts, a base made up of interlacing fibres and a semifluid matter interposed between them; the former he thinks similar to muscular fibre, and composed of an oxidated jelly, and the latter of a mucous or gelatinous character: upon which Dr. Bostock remarks, "The idea of the fibre consisting of oxidated jelly appears to be quite hypothetical, and, as far as we have any light thrown upon the subject by experiment, I should be led to the opposite conclusion, that the jelly is more oxidated than the fibrous part of the skin. Upon the whole it is probable that the fibrous part of the skin, which constitutes its proper substance or basis, is composed of albumen, like the other membranous bodies, and that it has intermixed with it a quantity of matter of a different chemical nature, which we may suppose to be a compound of jelly and mucus."* From the parings of hides as well as hoofs, &c. by mere boiling, sufficient of the gelatine is obtained to render them worth manufacturing into *glue*; the gelatine being reduced to proper toughness by evaporation. In this state, if kept dry, it will continue) unchanged for years; but if moistened, it soon becomes mouldy and putrid. The hide, however, serves to a much more important purpose, in the readiness of its combination with certain chemical agents, and the consequent production of *leather*, which is usually manufactured by exposure, after the hair and skin have been removed by soaking in lime water, of the hide, which has been subsequently allowed to become partially putrid, to the action of an infusion of oak bark, in which it is steeped till the hide has throughout obtained a brown colour. By this process the leather for boots, shoes, and harness, or such as is required to be thick and strong, is manufactured, and such is called *tanned* leather. The upper leather is not only tanned but *curried* by smearing with common oil whilst moist, which, as the moisture evaporates, penetrates the hide, rendering it supple and nearly water-proof. *Tawed* leather, which is used in the manufacture of gloves, is prepared by soaking the hide in a solution of alum and common salt, and afterwards treading it in a mixture of yolk of eggs and water.† A sort of leather is also produced by the astringent action of metallic salts, as sulphate of iron, oxymuriate of mercury, &c., which also protects it from the attacks of insects.

* See Breschet, *Op. cit.* p. 55.
† *Ibid.* p. 10.
‡ *Ibid.* p. 16.
‖ See his *Narrative of a Journey in the Interior of China*, p 45.

* See *Elementary System of Physiology*, vol. i. p. 89.
† See Aikin's *Dictionary*, article *Leather*.

*Vital characters.*—Blainville boldly asserts, "It is indisputable that the dermal tissue is itself insensible, and that to the nerves which traverse without blending with it belong alone that sensibility with which it might seem to be endowed:"* and he endeavours to support his opinion by reference to the less degree of pain produced by an incision through the skin from within to without, than if made from without to within. This, however, according to his own showing, depends on the division of the branches of the nerves previous to their extreme distribution, in which sensation resides, and therefore gives no support to his notion. Strictly speaking, neither this nor any other tissue, except the nervous, is sensitive; neither is it pretended to be so, but in the common acceptation of the term the hide is extremely so; it is, as Weber says, "the most sensitive part of the body," and whoever has experienced the severe agony induced by the slightly touching its surface when exposed by tearing off the skin immediately after vesication, will bear painful testimony to the truth of this assertion.

As to *Vital Contraction*, under the application of an irritant, or indeed under any circumstances, it does not occur in the hide. The production of "goose skin," as it is commonly called, on the application of cold to the surface of the body, merely depends on the emptying of the vessels of the hide, which, diminishing in all their dimensions, gather up as it were this tissue around the hair glands, and thus produce irregularities on the surface rendering it granular. The hide, however, possesses a certain degree of elasticity as has been already noticed, and it may also be observed, when a cut is made through the integuments either in the living or dead body, in which case the wound gapes to a greater or less extent in proportion as the tegument is more or less tense. This is called by Bichat "contractibility of tissue," but it results partly from the elasticity of the hide itself, and partly from that of the subjacent cellular tissue, which is proportionate to its laxity, for where the latter is close, as for instance on the skull, a wound of the scalp, though lengthy, will retract but little. The apparent motion of the hide of animals and of the scalp in the human subject does not therefore depend on any inherent moving power, but upon certain superficial muscles connected with it specially for that purpose, and, in many classes of animals, largely developed, as in those which have a hairy or feathery covering.

The hide, besides encasing all the organs of the body, and furnishing a bed for the expansion of the extreme branches of the nerves of touch, is a secreting organ, and provides itself in most, and probably in all animals, with a horny covering, of greater or less density, and sometimes containing earthy matter under various modifications, which, protecting the nervous papillæ from injury, in numerous instances does not interfere with their sensitive function; but, in other cases, so completely deprives them of such office, that a special apparatus is required for touch as it is for the other senses. The secretion furnished by the hide for its own protection is called either

SKIN, CUTICLE, OR EPIDERMIS,

and, together with horn in its various forms of nails, claws, beaks, teeth, feathers, &c., and with hairs, is included by Weber in his *Horny Tissue*, one of the two, *Dental Tissue* being the other, which make up his class of SIMPLE TISSUES. The latter tissue has been, however, within the last few years, proved to possess a high degree of organization, instead of being "a tissue" in which nerves and vessels, both sanguineous and lymphatic, elsewhere very generally distributed over the body, cannot be made evident, and in which but little or no cellular tissue is found.* Whilst, on the contrary, there seems reason to consider, as will be presently shown, that the skin is merely a secretion from the hide without claim to the character of a tissue; in other words, a product of the animal organism, by which title De Blainville calls "every substance, of whatever kind it may be, under whatever form it presents itself, which is found deposited in the organism (most commonly on the surface, but sometimes within some chamber or cell) without actually making part of that organism, and being capable of removal without injury, or even of detaching itself."†

*Physical characters.*—The skin is an exact repetition of the hide as to all its irregularities and inequalities; but is distinguished from it by the entire absence of nerves, vessels, or organized structure. It is homogeneous and without a trace of texture, overlaying the entire surface of the hide like a sheet of horny paper, and spreading also over the mucous tissue, (which will be hereafter spoken of,) where the special name of *epithelium* has been applied to it. In appearance it is yellowish, and more or less transparent in proportion to its thickness, which depends upon the degree of pressure to which it, or rather more correctly speaking, the hide is subjected; of this good example is presented in comparing the thin skin of the neck with the thick covering of the soles of the feet, or the thin soft palm of a delicate hand with the tough thick horny covering of the labourer's hand, arising out of the additional protection which the sensitive hide requires.

*Microscopic characters.*—No organic arrangement of the skin can be perceived by examination with the microscope; it still exhibits merely the same structureless disposition, but is found very extensively perforated with minute apertures, some of which are for the orifices of the sebaceous ducts, others for those of the perspiratory or mucous apparatus, and some for the transmission of the hairs, feathers, or scales. It is supposed by some writers that the skin is in itself arranged in a scale-like form. This notion has probably originated in the scaly, or more properly speaking, the branny form in which the skin often separates from the surface of uncleanly persons; but it would seem to be more probable, that the branny appearance is produced merely by the very small portions of skin which occupy the spaces between the numerous apertures already noticed. For if the skin be thrown off as it is in some animals entire, as in the shedding of the skin of reptiles, and of the horny covering of some insects, and in others as the skin of shells, in flakes, no such scaly character is exhibited, but it peels off as an entire sheath or in flakes,—a circumstance which also occurs not unfrequently after certain forms of disease in the human subject; as for instance, scarlet fever, and other eruptive fevers, or indeed in any severe inflammatory affection of the hide.

*Chemical characters.*—Skin is not soluble in boiling

* See his *Cours de Physiologie*, vol. ii. p. 70.

* See Weber, *loc. cit.* p. 170.

† See De Blainville, *loc. cit*, vol. iii. p. 3.

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water till after a very long time. It is soluble after a time in nitric acid, by which at first it is rendered yellow. Sulphuric acid also dissolves it, and renders it a deep brown pulp. Vauquelin thought it consisted of hardened mucus, and Hatchett that it was coagulated albumen. John* has given the following analysis of skin or cuticle from the sole of the human foot, from which it appears that, in 100 parts, there are of—

| | |
|---|---|
| Hardened albumen or horn . . | 93·0 to 95·0 |
| Gelatinous matter . . . . | 5·0 |
| Fat . . . . . . . . | 0·5 |
| Salts, acids, and oxides . . . | 1·0 |

The latter of which are lactic acid, lactate, phosphate, and sulphate of potass, sulphate and phosphate of lime, an ammoniacal salt, and traces of manganese and oxide of iron. It does not enter into any combination with tannin as do those membranes which, by boiling in water, give out a considerable quantity of gelatine, on which account, in the process of tanning, it is removed from the hide by steeping in caustic lime water. It is worth observation also that, according to Berthollet, the horny substance of skin is distinguished from the horny substance of hair by the blackening of the latter on the application of oxide of lead rubbed down in grease, owing to its combination with the sulphur contained in hair, which does not however take place in skin, the sulphur therein being in smaller quantity, and more closely connected with it.†

*Growth of skin.*—As the surface of the skin is continually wearing off by its friction against other substances, and as it therefore needs continual regeneration, the hide by which it is produced is constantly secreting it, and with such rapidity, that in the course of a few hours after the removal of skin by vesication, a delicate fresh layer is seen, soon rendering painless the surface of the hide, which but a very short time previous had been agonizingly painful on the slightest touch. In those animals which shed their skin entire, annually or more frequently, though the secretion is continually going on, yet doubtless it is more active at those particular periods, and it may be presumed that the shedding of the skin is caused by the increased vascular activity of the hide, which may be said to be in a kind of inflammatory condition, analogous to that state which in eruptive diseases detaches the entire skin covering the inflamed hide, whilst a new and completely distinct skin is formed beneath by the hide, which, perhaps during its inflamed condition, had for a time ceased to secrete; and when it again resumed its function, the new skin in its soft state was incapable of adhering to the original skin which had become dry throughout, and had no real connection with the hide beyond that which resulted from its entering into the mouths of the various ducts which opened on its surface, and into the depressions between the ridges of the hide, from which it was only discharged by the gradually forming new skin beneath thrusting it out.

When first poured forth from the vessels of the hide, the skin appears as a semi-fluid viscid matter, covering as a thin film the former in all its irregularities, just as a coat of varnish is spread over a picture or a piece of carving, differing only in this respect, that whilst the latter after a time becomes tough and hard throughout, the former is tough only on its external surface; for as its thickness is increased not by deposition on its external surface, as in the matter of varnish, but by the pouring forth of additional semi-fluid skin between the inner surface of the film of skin and the hide, the recent deposit is capable only of becoming tough and dry as it is thrust up towards the surface, and put in the most convenient place for the evaporation of its watery parts. The consequence of this drying of successive films of semi-fluid matter is, that the skin is made up of numerous thin layers or sheets of horny matter, those which are nearest the hide being most fluid, whilst those nearest the surface of the skin are most tough, and indeed, in such parts as are subject to much pressure, of nearly equal hardness with dry glue; and in this state are either worn away by attrition, or, becoming from their dryness very brittle, crack, break, and fall off in the shred-like branny form already mentioned. In reference to this point Weber observes, that if a layer of skin, either thick or thin, be shaved off with a sharp knife, it will be found that neither of the divided surfaces are smooth, that the irregularities of the hide are still observed on that portion of skin which remains on it, whilst corresponding irregularities exist upon the cut surface of the part which has been removed, and "therefore we perceive that the scarf skin is much disposed to separate itself into parallel superincumbent layers, and that these are rather split than cut by the sharp edge of the knife."*

The great difference as to consistence and toughness which the skin exhibits, in proportion as it is nearer to or more remote from the hide, has led many anatomists to consider them as distinct parts, the term cuticle being applied to the tough external superficial films, whilst the soft inner layers were distinguished by the name of mucous body or Malpighian net, from their discoverer; but they are one and the same thing in different conditions, the latter just secreted being semi-fluid, and the former being merely this semi-fluid matter rendered tough by the evaporation of its fluid parts. One of the readiest examples of this change of the skin from softness to hardness is observed in one of our greatest nuisances, the common cock-roach, a species of *Blatta*; this insect, as its body in the course of its growth becomes too large for its skin, sheds it continually, and is often seen in the act of escaping from, or just escaped from its horny coat;† at this time the skin is of a pale cream colour and quite soft, but in a very few hours hardens and acquires gradually its natural brown colour. That some change, however, does take place in its transition from the one to the other state is most probable; for if the skin be soaked in water, and its inner surface softens and dissolves, as it does whilst the outer is but little, if at all, in any degree changed, and certainly not dissolved, some alteration must have taken place, though upon what depending is not apparent.

This so-called *Mucous Body* has so much engaged the attention of anatomists, that it requires some special notice, and more particularly as it is the seat of the colours, which, painting the animal surface, appear through the transparent skin, and produce their various hues. It was first discovered by Malpighi upon the tongue of oxen, but his description is by no means precise. He states that, after removing the horny external covering of the tongue, "a certain glutinous substance

* See his *Chemische Schriften*, vol. vi. p. 95.
† See *Annales de Chimie*, vol. i. p. 50.

* See Weber. *Op. cit.* p. 185.
† Strictly speaking, the skin or cuticle of insects is not horny, but consists of a substance called *Chitine*, which will be hereafter referred to.



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presents itself spread over the upper surface of the principal part of the tongue, which, with moderate thickness, is strong; it is white in that part connected with the exaratæ membrane, but blackish where it is in contact with the interior (under?) part. It is expanded in form of a membrane, or of a thicker net; for it has distinct apertures corresponding to the exaratis horns, (horny coverings of the papillæ,) between which are detected by the microscope innumerable small passages of various form, which open upon the external surface of the tongue." "In each of the larger apertures formed in this nervous and glutinous substance, (in its white part,) about their concave sides, are observed portions of the same reticular or cribrous substance,* (the blackish part;)" and beneath this is the "nervous and papillary body, yellowish and whitish," which elsewhere, he says, is only the cutis or hide, and forming the papillæ, which "have at their base the nervous shoot to which they are appended, or rather upon which they grow." From this it would seem that he held the mucous body to be largely perforated with apertures, and hence speaks of it as "*per modum membranæ seu crassioris retis extenditur;*" elsewhere, however, speaking of the pyramidal papillæ as being found in other parts which have an extremely delicate sense of touch, as upon the tongue, he says, "*eodem progigni nervoso et cuticulari corpore simulque circumvolvi reticulari involucro et extimam cuticulam, veluti ultimum terminum attingere;*"† from which it may be fairly inferred, that the mucous body completely ensheathes the papillæ, and does not merely give them passage to the skin or cuticle, which view of the case is supported by his previous observation of the papillæ of a swine's foot after removing the hoof: "When I pluck off a certain blackish reticular covering (*subnigrum quoddam involucrum reticulare*) of the same nature as that I had observed upon the tongue, behold I expose oblong and almost pyramidal papillæ, which spring forth as a sword drawn from its scabbard."‡ Hence it would seem that all Malpighi means to state is, that upon the under side of this mucous body it has a reticulated or foraminated appearance, admitting the entrance of the papillæ, which are ensheathed by corresponding hollow processes of its own substance upon its upper surface; which is exactly what Albinus and Rudolphi show to be the case, when they confute the opinion of a reticular disposition of the mucous body, fathered by them and many others upon Malpighi, by stating that the holes in this body are caused only by the scalding or maceration necessary for separating it from the papillæ not having been continued sufficiently long to disunite completely the whole mucous sheath from each papilla, and therefore that the undisturbed portion still remains fast upon the papilla, whilst the loosened portion at its base tears from it, and thus leaves a hole.

Cruickshank and Baynham, and more recently Dutrochet and Gualtier, have considered the mucous body a distinct part of the external tegument; and the latter§ thinks it divisible into four distinct layers. 1. Every irregularity on the external surface of the hide is covered by a little button or bud, composed of minute arterial and venous branches twisted on themselves, and but slightly adherent to the hide, and upon the hands and feet ranged in grooves. 2. These buds, and the hide between them, are enveloped in a white thickish membrane, his *membrane albuginée*, formed by the buds, and which sends processes into the hide to form sheaths for the bulbs of the hairs. 3. Covering this membrane, another layer, easily distinguishable in the negro from its blackness, consisting of little bodies, in number corresponding to the buds, also composed of arteries and veins, and imbued with a peculiar colouring matter. 4. The membrane *albuginée superficielle* which envelopes the just mentioned membrane, and is interposed between it and the skin or cuticle. Of these four layers, the first and third are the vital parts, and perform the functions of exhalation and absorption, as well as secrete the second and fourth layers which have little vitality, and need continual reproduction. Admitting, however, its division into layers, he is certainly incorrect in enumerating the vascular surface of the hide as one of the layers of this mucous body; for even Beclard, who holds it distinct from both skin and hide, says, "This mucous body, of the nature of which it is difficult to give a very correct idea, appears to consist of a plastic liquid, or of a semi-organized cellular tissue. Neither blood nor injections show any vessels in it; some liquids however penetrate it, but they seem to be imbibed or contained in some peculiar interstices."* He considers, however, that it consists of three layers: 1. a very delicate and colourless layer upon the surface of the hide; 2. a coloured layer, which is often united to the 3. or superficial layer, which is colourless, more or less soft, or well encrusted with horny or calcareous substances. On the other hand, Bichat, Chaussier, Gordon, Rudolphi, and Weber deny that the so-called mucous body is other than the innermost layer of the skin or cuticle.

Breschet and Roussel de Vauzème thought they had discovered special organs for the secretion of skin, to which they applied the term *appareil blennogène*, consisting of numerous little reddish, bushy, unequal glands, grooved with blood-vessels, enveloped in a loose cellular tissue, and implanted in the deepest part of the hide, or even below it, in the adipose tissue; and that from each gland passes up a tube or canal through the whole thickness of the hide to terminate in the furrows between the papillæ, and together they often form a regular colonnade in the thickness of the head.† Gurlt, however, considers this statement incorrect, and that the so-called blennogenous glands correspond in position, form, and size with the sudoriparous glands, and that their ducts, differing only from the latter in being straight instead of wavy and in terminating in the furrows between the bases of the papillæ, are only the sudoriferous ducts not followed throughout their whole course. Admitting, however, that he cannot discover any proper organ for the purpose in man or animals, he holds that the entire surface of the hide secretes the Malpighian mucus, which subsequently hardens into skin.‡

This softer part of the skin is remarkable as being the seat of the colouring matter or *pigment*, upon which

* See his *Exercitatio Epistolica de Lingua*, in his *Opera Omnia, Epistolæ*, p. 14.

† See Malpighi, *Exercitatio Epistolica de Externo Tactus Organo*, p. 26.

‡ See *Ibid.* p. 23.

§ See his *Recherches Anatomiques sur le Système Cutane de l'Homme.*

* See his *Anatomie Générale*, p. 276.

† See Breschet and Vauzème, p. 73.

‡ See Gurlt, *Vergleichende Untersuchungen über die Haut des Menschen und der Haus-Säugethiere Besonders in Beziehung auf die Absonderungs-organe des Haut-Talges und des Schweisses*, in Meckel's *Archiv*. 1835, p. 406.

the varied hue of the skin depends. It is the *portio subnigra* of the *glutinosa quædam substantia* of Malpighi, to which later anatomists have specially applied the term *rete mucosum*. And, from having observed that the coloured skin could be removed from the toes of swine, from the lips and tongue of oxen, and from the soles of the feet of fowls, Malpighi says, "from which circumstance I deduce the probably not dissimilar cause of the blackness of negroes; for it is certain that in them the cutis is white together with the cuticle, wherefore the entire blackness must depend on the mucous and reticular body, because in different parts of the body it is of different colour, sometimes black as on the tongue, sometimes white as on the palate, and sometimes yellowish; I therefore think that same variety may occur in men."* According to Gualtier's notion, the pigment is deposited in the second layer of his mucous body, and he describes it under the name of *gemmules*, as an undulating layer, covering by a single turn each of the double grooved lines of the hide. It not only differs in colour in different animals and in different parts of the same animal, but varies as to shade of the same colour. Upon it depends the varied paintings not only of the skin, but even of the hairs, scales, feathers, &c., and the colour of the interior of the eye, showing through the pupil as well as that of the iris, results from it. In the skin of the negro it can be readily found, and also in the skin of the white, where however its existence has been denied by some anatomists; but in the skin of certain parts of the white person, it can be shown as satisfactorily as in the negro; for instance in the skin of the purse, and in the skin covering and surrounding the nipples of both male and female, to which has been applied specially the term *areola*. A remarkable circumstance is connected with the female areola, viz. the deepening of its colour during pregnancy, of which it is one of the most commonly known indications, as at this period it becomes in the fairest women brownish, and in dark females almost black.

That the pigment is contained in the softer part of the skin is proved by maceration, when that part of the newly formed skin nearest the tough external surface having become putrid, the latter separates colourless, leaving the pigment and viscous part of the skin still attached to the hide, and exhibiting the colour of the skin in much greater brilliancy than it shows through the semi-transparent external layer. But if the maceration be continued, the remaining viscum putrefies also, and the water becomes turbid by the disengagement of the pigment, which ultimately sinks to the bottom in form of an impalpable powder.

Breschet and De Vauzème consider there is a special apparatus for the secretion of the pigment, which they call *l'Appareil Chromatogène*, and describe it as situated "on the exterior of the hide at the bottom of the clefts, below and between the projecting papillary ridges. Its upper part is surmounted with an immense quantity of shortish excretory tubes, which open at the bottom of the grooves, where numerous tubes excrete a peculiar matter. Its under surface is rough with capillary vessels, and in relation with the excretory tubes of the blennogenous glands. Its structure is areolar, spongy, and resisting. This parenchyma and its excretory canals redden with great facility, as they are essentially vascular. Having removed the nutritient vessels of the papillæ, which rise a little higher when this tissue is torn, there are found an infinity of little filaments from which escape scales or uncoloured corpuscules in very large quantity. This reservoir of scales exists nowhere else in the hide."* Gurlt, however, will not admit this chromatogenous organ, for he says that Breschet assumes it in the tegument of white people where the skin is colourless, and that such apparatus is not to be found in all the other organs which have a brownish, black, or other coloured pigment, nor in morbid formation of pigment as melanosis.†

In a very interesting paper *On the Pigmentum Nigrum of the Eye*,‡ by Mr. T. Wharton Jones, this general colouring matter has been considered. He states that, in 1790, Carlo Mondini published in the *Commentationes Bononienses* his microscopical observations on the black pigment of the eye, and showed that it is not merely a mucus or varnish upon the choroid coat as formerly supposed, but a real membrane, formed, according to his notion, of innumerable globules, by the union of which an excessively delicate network is composed. The younger Mondini pursued the subject still further, and found that "the membrane composing the pigment, if examined with the microscope, appears composed of small oblong bodies analogous to globules, which are rendered more or less opaque by the presence of a multitude of small black points. The membrane has the same structure in the Mammola, but the globules are smaller in carnivorous and gnawing animals. In the young of certain species they are very white, but become yellow with age in the part called *tapetum*, which produces the azure or greenish appearance of the bottom of the eye in these animals. Mr. Jones, however, states that this membrane is "the seat of the pigment, but not the pigment itself," which may or may not be present; and that "if a portion of the membrane be examined by the aid of the microscope, it is seen to consist of very minute plates of an hexagonal form, accurately joined together by their edges, in which plates are deposited numerous black particles, which are to be considered as properly constituting the pigment, but not essential to the hexagonal plates composing the membrane; because these may and do exist without the black particles." He further observes, "As exactly analogous to the circumstance of the membrane of the pigment existing, although containing little colouring matter, I may mention, that the structure called *rete mucosum* exists in the skin of the white person as well as in that of the negro, with this difference, that in the former it contains little colouring matter, whilst in the latter it contains a large proportion of that matter, being the seat of it, but not the colouring matter itself."

According to Berzelius, the pigment of the eye is insoluble in water or in acids, though slightly soluble in alkalies; it burns as readily as vegetable matter, leaving behind it much iron, as does the colouring matter of the blood. Blumenbach, however, considers that the pigment of the skin is principally composed of carbon, which has been confirmed by the chemical observations of Davy and others. Burmeister states, upon the authority of Straus, that in some insects it readily dissolves in spirits of wine.

The production of the black pigment is to a certain

* See Malpighi, p. 26.

* See Breschet and De Vauzème, p. 74.

† See Gurlt in Meckel, p. 407.

‡ See *Edinburgh Medical and Surgical Journal*, vol. xl. p. 77, 1833.

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extent influenced by the sun's light and heat; freckling and even browning of those parts of the human body exposed to the sun is well known, either or both of which subside after a few weeks' removal from such exposure. The loss of colour, and its subsidence into more or less perfect whiteness, is very frequent in those animals which inhabit very low temperature, as seen in many beasts and birds of the arctic regions; whilst on the contrary among tropical birds, especially the colours, are most varied and most brilliant among all the inhabitants of the earth. From a comparison of the blackness of the negro with the whiteness of the northern nations, it has been held by some that the black hue is provided as a defence against the sun's heat; and this notion has seemed to have been supported by the deepening of the dusky colour of certain Portuguese Jews, who established themselves many years ago on the Malabar coast, and who are now so black as to be scarcely distinguishable from the aborigines. This, however, can scarcely be a correct reason of the dark colour, as black absorbs instead of reflects heat, whilst white on the contrary throws it off instead of imbibing. Whatever therefore be its use, this is certain, that sun-light and heat materially promote the production of the colouring matter, nearly equally in the animal and vegetable kingdom.

Whiteness of skin, hairs, and feathers, or parts of either, is common in many animals, and not to be considered in them as dependant on deficiency, but only on the paleness of the pigment. Occasionally, however, it happens that not only animals which naturally are coloured, but even individuals of the human race, are unnaturally white, sometimes in patches, when they are said to be *pieballed*, and at other times the whole surface has this appearance, when they are called *Albinos*; and it may be here remarked, that this abnormal character may be continued so as to produce a permanent variety in any particular species, as seen in white rabbits, peacocks, &c. In these cases, the want of the ordinary or natural colour of the animal depends upon the complete absence of pigment at the white parts; and it is an interesting circumstance, which assists in proving the identity of the colouring matter of the skin with that of the eye, that in albinos the choroid coat of that organ assumes a bright red colour, in consequence of the colour of the blood showing through its surface, which, naturally overspread with pigment, is in these cases deficient in such covering.

*The Use of the Skin* is more particularly to defend the extremely sensitive surface of the hide in those animals where it consists of little more than gelatine, and therefore not merely preserves it from læsion of every kind, but also from the effects of atmospheric changes.

The skin itself, however, under its ordinary exposure to heat, cold, moisture, &c. requires protection from their influence, otherwise it would become in many animals either too soft or too brittle, and thus either render little or no defence to the hide which it covers, or interfere with the motions and other functions of the parts contained within it. Indeed it, or rather the hide, even needs protection against the perspiration secreted within the tissue of the latter, and the annoying want of which is often exhibited in the chafing (which is really blistering) of those parts where the perspiration is confined even for a few hours. The natural and healthy condition of the skin, therefore, requiring to be preserved by a kind of oiling or greasing, it will be preferable to consider the apparatus provided for this purpose, previously to examining that by which the perspiration is produced.



Sebaceous Glands.—*Glandulæ seu Cryptæ Sebaceæ.*

In their most simple form, each consists of a club-shaped cavity, sunk more or less deeply into the hide, lined with a funnel-shaped process of the skin, the mouth of which opens between the papillæ. But when more complicated, one or more glandular clusters is seen, the duct belonging to each of which opens into a flask-like hollow, which also serves the purpose of a sheath to a hair. These glands are sometimes disposed in irregular masses, as may be seen about the wings of the nose, upon the gristles of the ears, and the passage leading down to the membrane of the drum, and about the latter parts are called *ceruminous glands*, from their secretion being vulgarly called *ear-wax*; but along the edges of the eyelids they are placed in rows, and are called from their discoverer Meibomian glands; their secretion is called by the Germans *Augenbutter* or eye-butter, which is more appropriate than our name *gum*. In many animals there are cavities or sacs of some size, upon the sides of which the sebaceous ducts open; such are the claw bags of cleft-hoofed beasts, the sebaceous bags around the udders of sheep, together with the tear-pits of deer, anal sacs of carnivorous animals, and the pores upon the thighs of many reptiles. Where the surface is covered with hair, the ducts of the sebaceous glands terminate in the hair follicles or bags; but if there be no hair, as on certain parts of the body, they terminate directly upon the surface, and are lined partially by an engulfing of the common tegument, which in those animals having coloured skin can be distinctly traced into the ducts, which only become colourless as they descend deeper into the hide. The secretion from these glands is called *sebacine*; it is the "expressed oil poured out more slowly," according to Cruickshank's observation, "by the perspiring vessels of the skin,"* which he discovered by wearing night and day the same fleecy hosiery vest during the hottest part of summer for a month, when he found "this oil accumulated in considerable masses, on the nap of the internal surface of this covering, nearly in the form of black tears;"† and having scraped off about a scruple of this matter, and exposed it in a spoon to a red heat, it burnt with a white flame, and left behind it a black powder in every thing resembling charcoal. The ear-wax has been examined by Fourcroy and Vauquelin, who state that it contains an oil soluble in æther, but not so in spirits of wine, together with a bitter yellowish matter, insoluble in spirit and albumen. The fœtus *in utero* has its whole surface anointed with this secretion, which is then called *vernix caseosa*, to protect it from injury by the amniotic liquor. The sebacine in weakly unhealthy persons is often secreted in large quantities, or from some accidental cause cannot readily escape by its ducts; under such circumstances its watery parts evaporate, and becoming inspissated and hard like butter, that part of it near the mouth of the duct is blackened by dirt, as frequently seen on the sides of the nose and upon the face, where such inspissations are

* See his *Experiments on the Insensible Perspiration of the Human Body*, p. 93.

† *Ibid.* p. 94.

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vulgarly known as *blackheads*; and if the skin beside them be pressed, the secretion is ejected in form of little spiral cylinders, which are improperly called *worms*.

The peculiar odour of different persons depends on the sebacine: thus particular races of coloured people, and even certain complexioned white persons, have frequently an exceedingly offensive odour, although not in themselves uncleanly. On the contrary, as Dr. Elliotson humourously observes in his notes to Blumenbach's *Physiology*, p. 182, "The odour of some persons is said to have been quite a perfume. In the *Memoirs of the Queen of Navarre* we read that Catharine de Medicis was a nosegay, and Cajucius the civilian, and Lord Cherbury, were equally delightful." Certain parts of the body have always a special and disagreeable smell arising from the same cause. In brutes this is especially the case, so that even at a distance the presence of certain animals, as for instance the boar, is readily perceived at a very considerable distance; the odour from goats and cows is well known. Mosk is the sebacine of particular parts of the Musk, *Moschus Moschiferus*, Lin. and Castor from the same parts in the Beaver, *Castor Fiber*, Lin.; and to these numerous other examples might be added.

The *Use of the Sebacine* is to preserve the proper softness of the skin, just as oiling leather renders it supple, and at the same time securing it against the acridity of the perspiration. It also regulates the temperature to which the skin is exposed, and serves the purpose of an antiepispastic; for if, as not unfrequently happens, after exposure to the heat of the sun, the ducts of the sebaceous glands are either closed by the constriction of the skin around them and cannot extrude the secretion, or if the glands themselves are inflamed from the same cause and do not secrete, the skin is very speedily sunburnt as it is called, and often very severely blistered. In brutes, the peculiar odour of the sebacine is often connected with the sexual functions, and puts the male on the scent for its mate.

Perspiratory Glands.—*Glandulæ Sudoriparæ.*

The discovery of the perspiratory apparatus has only taken place within the last few years, but the mouths of their ducts appear to have been known to Malpighi, for, in speaking of the ridges on the cuticle or skin of the palm of the hand, he says, "*in extremo tamen digitorum apice spiraliter ductæ, si microscopio perquirantur*, patentia sudoris ora *per medium protracti dorsi exhibent*;" and a little further on he observes, "*bini papillarum ordines paralleli per longum ducuntur, in quorum medio dispersa locantur* sudoris vasa."* About 1684, they were described and figured by Grew in the *Philosophical Transactions*, p. 566, for that year; he says, "On these ridges (of the palm of the hand) stand the pores, all in even rows, and of such magnitude as to be visible to a good eye without a glass. But being viewed with one, every pore looks like a little fountain, and the sweat may be seen to stand therein as clear as rock-water, and as often as it is wiped off, to spring up within them again. Dr. William Hunter described and delineated in the *London Medical Essay* white filaments passing between the skin and hide, and most remarkable in the sole of the foot in the human subject, which he suspected to be vessels

* *De Externo Tactus Organo*, p. 25.

of perspiration continued even to the cuticle or skin. Upon which Cruikshank observes, "if they are vessels, it corresponds with my idea of vessels becoming larger and longer, in proportion as the cuticle becomes thicker."* Albinus and Meckel, however, did not admit, or perhaps might have been unaware of these observations, and held that whatever fluids were perspired soaked through the skin, like the steam of warm water through leather. Albinus was inclined to believe that the perspired fluids oozed through the coats of the extreme arteries themselves as vapour, and afterwards condensed into sweat; and adds, "*quid ni penetraret, per mollia nostra humidaque, quum calentis aquæ vapor, per durum siccumque corium eo modo penetret?*" And Meckel, speaking of the skin, says, "*Quoiqu'inaccessible aux vaisseaux, sa nature est pourtant telle, qu'il transmet le liquide, dont il est imbu à peu près, comme pourroit le faire un cuir mince humecté.*" In noticing these opinions, Cruickshank observes, "I cannot help being persuaded, that such a process as soaking, however it may take place in dead animal substance or vegetable, is a process too much allied to those of dead matter to have any place in a living body. Nay, I think it may be proved, it never does take place in the cuticle even in the dead body."† In support of this opinion, he states his belief, "that there are pores organized connected with the extremities of the exhalant arteries in the cuticle and rete mucosum, which, however invisible in the dead separated cuticle, still exist, and are sufficiently dilated in the erected state of the extremities of the vessels of the living and perspiring skin." And further, in accounting for the seeming absence of the holes by which the pores open on the surface of the skin, he says, "I perforated pieces of cuticle with a fine needle, but these perforations were invisible in the microscope, as they would have been had I perforated the elastic gum." Beclard, however, still held to the old opinion that no pores exist in the skin, as he failed to discover them even although he loaded a piece of skin with mercury to the weight of one atmosphere. And a little further on, he says, "The secretion (of the perspiration) takes place on the skin, (hide,) but we know not by what vessels; as to the canals by which it traverses the mucous body and epidermis they are entirely unknown. We may admit, with some probability, that at the bottom of the microscopic clefts and hollows of the epidermis, where it is least dry, the perspiratory excretion specially takes place."‡

The discovery of the perspiratory apparatus was made nearly at the same time by Purkinje and Breschet and De Vauzème. Purkinje's description was made public in 1833 by Wendt, in his Inaugural Treatise *De Epidermide Humana*, and subsequently it was noticed in Müller's *Archiv. für Anatomie, &c.*, 1834, p. 30. Having hardened and rendered the hide transparent by treating it with *liquor potassæ carbonatis* and raised the skin, Purkinje observed the perspiratory ducts like thin threads passing down and taking a spiral course from the little pores on the elevated lines of the palm of the hand and sole of the foot, and through the Malpighian or mucous layer to the hide itself, through which they also pass, no longer spiral but straight and gradually swelling out, terminate in a blind rounded extremity;

* See Cruickshank, p. 24.

† See his *Experiments on the Insensible Perspiration of the Human Body*, p. 11 *et passim*.

‡ See Beclard, p. 287.

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the length of each canal being scarcely more than twice the thickness of the skin, or cuticle of the palms or sole. A remarkable verification this of Cruickshank's statement, that it is "probable at least that the first perspiring and absorbing pores are in the processes or *vaginulæ* of the cuticle and *rete mucosum*, and that those which appear on the outside surface are secondary, resemble mucous ducts, and are common to a vast number of the primary pores."* Wendt further observed the turns of the spiral in the right hand were from left to right, and in the left hand in the contrary direction. In 1834, appeared Breschet and De Vauzème's account of the perspiratory apparatus, which they call *l'Appareil Diapnogène*. They merely employed a piece of the tegument macerated or dipped in hot water, and, having raised the skin from the hide, saw with the naked eye the excretory canals or ducts elongate themselves indefinitely like the threads of a spider's web, as their spirals unrolled. Under the microscope they exhibited a surface covered with horny matter, imbricated as it were upon a central canal. And by the same means, they observed the egress of the canals between the papillæ and their penetration of the horny matter which fills like a wedge the interstitial funnel of the papillæ.† The secreting parenchyma is placed in the substance of the hide in form of a slightly swelling bag surrounded with capillary vessels, and from it is sent up a spiroid canal which passes obliquely through the horny layer or skin, in form of a corkscrew or the worm of an alembic, to the surface, where its termination is indicated by a slight depression or kind of pore on the top of the projecting ridges of the skin. With regard to the bag or sudoriparous gland, Gurlt says,‡ it is always situated in the deepest layer of the hide, and often descends below it into the adipose tissue, by which it is readily distinguished from a sebaceous gland; they also differ somewhat in size and form, being larger on the palms and soles than in other parts, and generally of a roundish oval form, but upon the head more elongated. About the generative organs of horses, they are larger than in man, visible to the naked eye, and of an oval shape, but in other parts of the tegument smaller and more oblong. In oxen, the glands are very small and round and universally of the same size. In sheep, in proportion to the thinness of their skin, they are large, but vary in size at different parts. In swine, they are oblong and of similar size to those in the hairy parts of horses. In the dog, they are round and large upon the foot-pads, but elsewhere very small, oblong, and difficult to be found. The glands are generally colourless and transparent, but upon those parts of the horse specially noticed above, they are brownish, which depends upon the presence of some little brown granules; in the foot-pads of dogs the granules exist, but are colourless. Gerber's account of these glands differs from those already mentioned, as he states that "they consist either of a mass (*knaul*) of bags, so that they have a cluster-like appearance, as in man and all domestic animals, or are simple bags, as commonly in cattle and occasionally in carnivorous animals.§ The ducts Gurlt considers as very probably descending processes of the tegument, for in those animals which have a coloured hide, the same colour is seen at the upper part of the ducts which only become colourless and transparent as they descend; he also states, that they can be drawn out of the gland.

* See Cruickshank, p. 14.
† See Breschet et Vauzeme, p. 26 *et passim*.
‡ See in Meckel, *Archiv.* for 1835, p. 414.
§ See his *Handbuch der Allgemeinen Anatomie des Menschen und der Haussäugthiere*, p. 78.

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The *Perspiration* which is secreted by the sudoriparous glands is continually produced over the whole surface of the bodies of some orders of animals though not always apparent, whence it has commonly obtained the name of *Insensible Perspiration* to distinguish it from *perspiration* or *sweat* as it is called, when the secretion is very rapid, and apparent on the surface in form of watery globules or drops. Many writers have endeavoured to establish a distinction between the two, considering that the perspiration is more aqueous than the sweat, and that the latter is more saline than the former; but without reason, for, as Blainville observes, "all the difference between them consists in the degree of cohesion, which depends on the temperature of the animal, and on that of the atmosphere;" thus if the temperature of the animal and of the atmosphere be similar, and the perspiratory process not excited, the secretion passes off, or is dissipated in the air, without being observable, as may be noticed in a horse standing in a warm stable; but if the door be opened and stream of cold air admitted its hide begins to steam slightly, the perspiration being condensed by the diminished temperature. So, again, in exercise, where the perspiratory function is very active, in summer time a horse, though streaming with sweat, scarcely if at all smokes, whilst under the same circumstances in cold weather, it is enveloped in a vapoury mist which almost hides it. Boerhaave says that if the hand be introduced in summer into the powdered ice of an icehouse, it smokes and gives the same appearance as the breath does in winter; and he amusingly remarks, that if winter's cold could be suddenly produced in the midst of a summer assembly, that each individual would then appear like a heathen deity wrapped up in his own cloud. Winslow further states, that he could show the insensible perspiration by opposing his naked head to a white wall, on a fine summer's day, when the vapour will become visible (magnified, as he says, by the sun's rays, but it should be rather condensed by the coolness of the wall) and appear ascending like smoke. So in the numerous experiments which have been made by inserting a limb in a closed glass, to ascertain the quantity of perspiration formed in a given time, perspiration or sweat has been collected in considerable quantity and rendered apparent by its condensation upon the sides of the vessel, without the condition of the limb having been otherwise different from the other parts of the body, excepting that it has been removed from the influence of the open atmosphere, and therefore the ordinary evaporation from the surface prevented. Some parts of the body perspire more freely than others, which seems to depend on the thinness of the hide, at least the function is most active on thin-skinned parts, as in the armpits, groins, &c.

Various experiments have been made to ascertain the quantity of perspiration produced by the human body in the course of twenty-four hours. Sanctorius's chair is well known, by which he endeavoured to determine the quantity of alimentary matter which, after being taken into the body, was thrown off or excreted, and not applied to the sustentation of the system. According to his account, in the warm climate of Italy five-eighths were got rid of by the perspiration, and only

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Zoology. three-eighths by the other excretory processes, and eighty ounces of perspiration were daily given off; but as Beclard observes, he made no distinction between the quantity of fluid thrown off by the external tegument and that which is disengaged by the lungs. Gorter, in Holland, could only obtain from forty-six to fifty-six; and Keil, in England, but from thirty-one to forty-one ounces in the same time. More precise and therefore more satisfactory were the experiments of Lavoisier and Seguin,* who ascertained that the average loss by the cutaneous and pulmonary perspiration was from seventeen to eighteen grains in a minute, the least quantity being eleven and the greatest thirty-two grains. But Seguin went still further, being determined to ascertain the relative amounts of the so called pulmonary, and the cutaneous perspiration; for which purpose he invested himself in an air-tight dress, (silk varnished with Indian rubber,) with a copper mouth-piece, which having been carefully gummed to the skin about his mouth, he was weighed and remained quiet for some hours, after which he was again weighed, and the result of the computation of the experiment showed that the mean exhalation from the lungs was fifteen ounces, and of the cutaneous perspiration thirty ounces in the course of twenty-four hours. But he also observes that whatever be the quantity of food taken, if no exertion be used, the weight of the body returns to the same standard in twenty-four hours—that if, under similar circumstances, the loss by exhalation is diminished, the other fluid and solid excretions increase proportionally—that in imperfect digestion the exhalation is less active, but that if it be good, the quantity of food taken has no great influence upon it, and that it is in least activity just after feeding.

*Chemical Characters.*—The perspiration is colourless, has a saline taste, very soon becomes acid, and reddens an infusion of turnsol; but chemists dispute as to the kind of acid. According to Thenard, who collected it in a flannel shirt, the perspiration consists of water in various quantities, free *acetic* acid in tolerably large quantities, chloride of sodium, some phosphate of soda, traces of phosphate of lime and oxide of iron, together with an animal substance. Berzelius's examination of drops of perspiration from the forehead gave *lactic* acid, lactate of soda, chloride of sodium and chloride of potassium, muriate of ammonia, and a small quantity of matter soluble in alcohol (osmazome). Cruickshank, in experiments he made to ascertain the affinity between matter of insensible perspiration and the vapour of the lungs, found that the perspiration he collected did not render lime-water turbid when added to it, but that if lime-water were thrown into the vessel in which the experiment had been performed, it then became turbid as when mixed with air in which a wax taper had burnt till it had become extinguished; he therefore "inferred (in the language of his time) that, (admitting the common theory of fixed air and phlogiston) something passed off with the vapour of insensible perspiration by the skin, which rendered air fixed;"† in other words, that carbonic acid gas was given off with the perspiration, as Mr. Abernethy subsequently stated, and calculated that "if the perspiration of all parts were equal, seventy-seven drachm measures of carbonic gas would be emitted, and one-third of oxygenous gas, in the space of an hour." The correctness of these observations of Cruickshank and Abernethy has been proved by the experiments of Collard de Martigny, who collected the gas evolved from the skin by placing over it a glass funnel, stoppered and filled with distilled water, and hence infers that the carbonic acid is exhaled in the gaseous form, since it is produced without the contact of atmospheric air.* Anselmino collected perspiration by placing his arm in a glass cylinder, and surrounding the aperture with oiled silk, and the fluid condensed on its sides in form of drops which, upon examination, he found to contain carbonic acid, acetic acid, and ammonia. And having collected for another experiment the perspiration by spunging the bodies of several persons, he gives a further account of the analysis of the dried residue, in one hundred parts of which he found

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|---|---|
| Matters insoluble in water and alcohol (chiefly calcareous salts) | 2 |
| Animal matter soluble in water, insoluble in alcohol, or salivary matter, and salts of sulphuric acid | 21 |
| Matters soluble in dilute alcohol (chloride of sodium and osmazome) | 48 |
| Matters soluble in pure alcohol (osmazome alkaline acetates and acetic acid) | 29 |

He also found in the ash of the dried residue, carbonate, sulphate, and phosphate of soda, and some potash with chloride of sodium, phosphate and carbonate of lime, and traces of oxide of iron.†

Blainville observes‡ that the difference observed between these experiments of Anselmino is probably referable to the method by which the perspiration was obtained, it being collected, in the former case, in a glass vessel, and in the latter by a sponge passed over the body of various persons; the quantity of the first was also small, whilst of the latter it was large, which might perhaps explain why, after evaporation, the precisely same components were not obtained: and with regard to the ammonia, he thinks it may perhaps have been produced by the decomposition of the perspiration which readily putrefies. Blainville also states, that in infancy the perspiration is more acid than at subsequent periods, and that it has often a smell of vinegar: this is certainly the case, but must be considered rather as a morbid than as a natural condition.

*Use.*—Besides throwing off a considerable quantity of the watery part of the blood, as well as ridding it of carbon, and thereby assisting the lungs, with the function of which it has been already shown to have close connection, the perspiration also mainly contributes to the preservation of one regular temperature of the body even under exposure to great heat, by the cooling effect of its increased secretion under such circumstances. The experiments of Fordyce, Blagden, and others, upon this point, are well known. Blagden and others supported a temperature of 260° in dry air for eight minutes. The writer of this treatise has been shut up in Sir Francis Chantrey's oven for some minutes at a temperature of 210°; the sensation at first entrance was almost stifling,

* See *Mémoires de l'Académie des Sciences*, 1790.
† See Cruickshank, *loc. cit.* p. 83.

* See his paper in Magendie's *Journal de Physiologie*, vol. x. p. 162.
† See his paper in *Journal Complémentaire des Sciences Médicales*, March, 1827; and in *Journal des Progrès des Sciences et Institutions Médicales*, vol. ii. p. 121.
‡ See his *Cours de Physiologie Génér. et Comp.*, vol. iii. p. 49.

Zoology. but immediately that the perspiration became profuse, (which it did very speedily,) all uneasiness ceased, and respiration was perfectly free. Delaroche however observed, that if the heated air were saturated with moisture, the temperature of the animal rose four, seven, and even nine degrees above the surrounding atmosphere. As Seguin's experiments indicate that the quantity of perspiration has so close a relation to the food and to the other excretions, it will readily be conceived, why any interference with its ordinary production should materially affect the system; thus every one understands the expression " being chilled" by sudden exposure to reduced temperature after leaving a hot room, and the frequently consequent " catching cold:" this depends upon the perspiratory action being checked, and more blood than naturally being thrown upon some one or other of the internal organs: thus when the membranes of the air-passages are affected, catarrh and even inflammation of the lungs are consequent on such exposure, and in persons whose alimentary canal is irritable, not unfrequently diarrhœa from the same cause.

It appears that only a very small number of animals enjoy cutaneous perspiration to such a degree as to be apparent; man and the horse, however, perspire very remarkably; cattle and rats also sweat, and it is said the monkey family also; but neither dogs, foxes, nor wolves, which are all of the same genus, sweat by the skin, or, if they do, only in a very trifling degree; compensation however is made by the free exhalation which takes place from the tongue and from the lining of the mouth, a fact which is well known to the most careless observer. In reference to this point, Blainville observes, " In three-fourths, I would even say seven-eighths, of mammals, this function never produces perspiration sufficiently abundant to be collected in a liquid state upon the surface of the body."* The perspiration in frogs, and perhaps in others of the same order of reptiles, is very free, and though at its minimum, even in the moistest air and in water, as observed by Milne Edwards.

The perspiration is also doubtless of material assistance in discharging from the body such parts as have served their purpose in the animal economy, and require removal. It is therefore in close relation with the respiratory and urinary functions; and with the latter connection almost every one is well acquainted, because it is exceedingly apparent: for in hot weather the perspiration is secreted very freely, whilst the urinary secretion is scanty; but, on the contrary, in cold temperature, the secretion from the skin is checked, but in exact proportion is that of the urine increased. Its connection with the respiratory process is also equally close, and is rendered especially apparent in injuries or disease by which the perspiration is interfered with: if large portions of the hide be destroyed by severe burns or scalds, the perspiratory apparatus being destroyed, its functions cease, and more blood being thrown upon the lungs, which offer the readiest means for discharging those matters usually gotten rid of by the perspiration, they become overloaded, unequal to the performance of the additional duty imposed upon them, and either assume an inflammatory action which puts an end to life, or are so gorged or congested with blood, that they are rendered incapable of fulfilling their office, which gives rise to similar fatal results. So in fever, where the surface of the body becomes extremely hot and dry, and the perspiratory function suspended from the vessels of the hide being subjected to a sort of inflammatory action, more blood is sent to the lungs, as is evidenced by the hurried respiration, and this state of things, as is well known, frequently terminates in inflammation of the respiratory organs.

As to what is removed by perspiration, Müller observes, that " it appears indeed that by the perspiration, especially those parts are separated, which by the ordinary temperature of the body can assume a gaseous form, whilst the more fluid are discharged by the urine."*

Having now considered the structure and function of the hide in the human subject, with reference to its production of the skin as a defensive sheath to the whole surface, and also as the bed in which the perspiratory apparatus is disposed, the functions of which are commonly described as belonging to those of the hide itself, the next points to be considered are the modifications which the hide undergoes for the production of nails and hairs; but as these are subjects materially connected with brutes at large, and as a gradual chain can be shown to exist which connect the simple structure of the skin with the complicated formation of hairs and feathers, which latter are the most extreme point to which the modification of the hide extends, it will be more preferable to consider them in their proper place in the scale of cuticular or skin productions.

### *Of the Modifications of the Hide and Skin in the several Classes of Animals.*

The external tegument exhibits great variety in different animals; it is thinnest in birds and in the family of frogs; thickest in pachydermatous animals and in the whales, and in either case, generally, though not always, the skin and hide are correspondently thin or thick, and most commonly the tegument on the back is considerably thicker than on the belly, or at the flexures of the limbs. The skin is much thinner in those animals which are covered with scales, hairs, or feathers, than in those where it is bare, except only on such parts of an animal as are extremely sensitive, and in which the organs of touch are fully developed, as is seen in the lips, muzzles, trunks, and tails of many animals, as the horse, hog, elephant, opossum, &c., and also in those birds which for the same purpose have the beak covered with very soft, horny skin, as the woodcock, duck, &c. The papillary character of the hide of these parts is exhibited by the corresponding appearance of the skin overspreading it, and indicates its use as an organ of sensation. On other parts of the body the tegument exhibits more or less distinctly the alternate elevations and grooves seen on the surface of the human body, and these are very decided in the coat of the elephant. In birds the arrangement of the grooves is in form of delicate quincunces, at the angles of which the feathers are attached, and hence the cuticle when it separates assumes this form, and gives rise to the scaly appearance which the skin of birds is described as exhibiting. The surface of the whale family, on the contrary, presents neither ridges nor grooves, but is quite smooth, shiny, and semitransparent. In the frog-like reptiles, the skin is also extremely smooth and thin, as is

* See Blainville, *loc. cit.* vol. iii. p. 59.

* See his *Physiologie*, p. 565.

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also their hide, which is remarkable for being very loosely connected with the subjacent parts, and also for being largely imbued with mucus, to fit it for exposure to water, in which respect it resembles the tegument of fishes, instead of the sebaceous secretion occurring in other animals of its own class, and also in those of birds and beasts. The naked skin of those animals of the invertebral class which live in water are also largely furnished with mucus, as the cephalopodous molluscs, the cuttle fish, for example, and some even of those which live on land, as the slug. Such then are the general modifications which the hide and skin exhibit in the animal kingdom; but there are some modifications of a more marked character which require special consideration, beginning with the simplest form, callosities and pads, and thence by numerous gradations passing up to the most complicated structures of hair and feather.

### a. Callosities or Pads, *Calli*.

Callosities are the patches of thick skin found on those parts of animals which are more particularly exposed to pressure and friction. They are seen on the rumps of very many of the family of monkeys, on the knees and chest of camels, and on the knees and chest of ostriches; they are entirely destitute of hair, have a laminated appearance, as the skin wearing out separates and scales off, and have merely a horny colour, more or less deep, according to their thickness. The hide by which they are secreted is thick, and between it and the bony parts which it covers is a mass of fat intermingled with fibrous matter, forming a cushion to relieve the effects of pressure.

Footpads, as those callosities are called, which are found on the soles of the feet of all many-toed animals, in the classes of beasts, birds, and reptiles, are distinguished, especially in those animals which walk either on the whole or on part of the under surface of the toes, by the papillary character of the skin, which is merely a repetition of the papillæ of the hide, remarkably developed in these pads: they do not flake off like other callosities, the skin appearing to be deposited in vertical, instead of horizontal layers, and hence the papillary appearance is always preserved, as may be seen on the soles of the feet and toes, especially in the cat and dog kind. The footpads of the elephant, Cuvier describes as being "divided externally (inferiorly) by deep grooves nearly circular, into six or eight, more or less, compartments, each of which incloses an infinite number of little polygons still more irregular, which renders the surface of the skin as it were shagreened. This epidermis (skin), being detached from the animal, and examined on its internal (upper) surface, exhibits very elevated lines in place of the grooves which bound the great polygons, and also others still smaller which correspond to the little polygons. Hence is produced a kind of trellis in relief, of a tolerably regular design, resembling lace with large points."* The pads are very commonly coloured by the pigment on the surface of the hide, which further distinguishes them from callosities. It may also be remarked, that the pads do not cover the whole surface of the feet and toes, but only such parts as are exposed to pressure, as may be seen on comparing the foot of the dog with that of the badger; their existence, therefore, enables us readily to determine whether the animal be plantigrade or walking on the whole surface of the foot, or digitigrade or moving only upon the under surface of the toes. The footpads are very distinctly observed in the foot of birds at that part improperly called the heel, which is really the covering of the lower end of the tarsus or leg, commonly so called, beneath which the tendons pass into the foot or under surface of the toes, protected by the thick fatty stuffing of the pad.

### b. Plates, *Clypei et Loricæ*.

The tegument of many animals is divided into larger or smaller segments: the former, from their size and disposition resembling plate armour, are called Plates, whilst the latter, being similar in its reticular appearance to a mail shirt, may be called Mail. The most striking example of the former is presented in the hide of the rhinoceros, whilst the flat tail of the beaver and the skin of snakes exhibit the latter. In reality, however, the difference between them is little more than in size, although the smaller plates are very commonly, though improperly, called *scales*, if that term be restricted to a plate overlapping and overlapped by others. Such overlapping plates, however, do exist on the legs of birds, and on the bellies of many reptiles, but they are entirely different from true scales, except in form, and should therefore be distinguished as Scale-like Plates.

In treating of the dermal tissue, it was stated that always opposite the flexures of joints, there are seen lengthened grooves of various depth, extent, and direction, for the purpose of dividing the skin and hide into segments so as to prevent interference with the free motions of the joints, the thinner parts traversed by these grooves allowing the segments of the thicker tegument to approximate and alter their position, thus facilitating the motions of the limbs or parts of them, which could not take place so readily, or, if the hide fitted very closely, not at all, without such division. That this is the fact appears from examination of the fins of cetaceous animals, among others including the porpoises and whales; in them the bones of the hand and fingers exist, but their undivided covering entirely prevents their motion, both as a whole or simple limb. The entire covering of their body is also similarly circumstanced, and can only be bent like a piece of leather, so far as its elasticity will admit. On the contrary, the hide of the elephant, although thick, has numerous segmental grooves, admitting free motion and even wrinkling. But the use of such division into plates is more readily and distinctly observable in the rhinoceros, of which the hide is very tough and thick, and without division would as completely prevent its motions as if soldered up in jointless armour; it is, however, divided into several segments like the pieces of plate armour, specially at the bottom of the neck behind the shoulder and in front of the hind quarters, every two pieces being connected by a softer portion of the hide, which juts out in folds between the plates, and thus admits, to a certain extent, the motions of the several parts of the body on each other.

Almost precisely similar to this horny armour is that overspreading the whole surface of the crocodiles and the head and shell of the whole order of turtles (excepting one genus), which are not truly scales, but merely pieces of tegument of various thickness and

* See his *Leçons d'Anatomie Comparée*, vol. ii. p. 543.



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form, in which the skin contains more horny matter than that by which the edges of these plates are connected with each other. In the crocodiles, the object is to facilitate the motions of the body and limbs in any directions, but in the turtles, where the parts so covered are bony, there is no such purpose to be effected, and it seems only to exist as forming part of the general plan upon which animal beings are formed. In ophidian reptiles or serpents the tegument is disposed on the back and sides in innumerable small polygonal pieces connected at their edges by hide, which secretes less horn, and from its elasticity admitting the separation of these little plates from each other, an arrangement which is necessary for animals often gorging prey two or three times exceeding their own bulk, as, for instance, the common snake swallowing a large frog: for were the hide covered with an undivided skin it would not dilate as it is known to do with its polygonal divisions. The tail of the rat and more especially the trowel-like tail of the beaver have the same reticulated or polygonal form of the tegument; and the legs (tarsi) and toes of many birds present the same appearance. In neither of these, however, is there any separation of the plates required or permitted.

The disposition of the tegument on the back of the legs of many birds, as for instance of the turkey, and also on the bellies of serpents, present the transition from the comparatively smooth surface of the Simple and Mailed Plates just mentioned to the Scale-like Plates. In this arrangement, the hide, together with its investing skin, is folded up into distinct transverse plaits which overlap one another, and present the appearance of a row of tiles ranged lengthways upon each other, and the skin at the base of the plait is connected by a thinner portion with that which precedes and that which follows it, so that when the skin and hide have been detached by putrefaction or boiling, the latter can be withdrawn from the former, leaving the plait of hide and itself presenting a correspondent horny mould. No special apparatus is here required; the hide exhibits nearly the same appearance of delicate papillæ as on any other part of the body from which the skin has been removed.

The difference between these plaits of the tegument (*scutu*, as they are commonly called) and the Scale-like Plates consists in the plaits being divided into numerous tongue-like processes, which have their bases in each row alternately shifted, so that every single plait is overlapped by the adjoining halves of the two in the row immediately before it, exactly like flat tiles or slates on the roof of a house. These tongue-like processes are enveloped in horny sheaths of corresponding form, which are thicker on their outer than on their inner leaf, but the two, joining together and projecting beyond the tip of the dermal process, form a solid and entirely horny tip. Such Scale-like Plates cover the upper surface and sides of the pangolins, and also their tails and legs, also the bodies, limbs and tails of the skinks and others among reptiles, the legs of turtles, and the tails of many lizards.

These Scale-like Plates, as indeed also the plaited plates, are constantly growing, so that as their tips or free extremities wear out, they are continually reproduced, and thus form a connecting link with many of the growths which are immediately to be considered, especially nails and hoofs; whilst the Mail-Plates in their annual shedding resemble the periodical shedding of the hair in beasts, and the moult of the feathers of birds.



Nails, claws, hoofs, horns, beaks, scales, hairs, and feathers, are distinguished from the dermal growths already mentioned, in having a very peculiar disposition of that structure, or perhaps even some superadded matter for the purpose of their formation; and after a certain extent of growth they become entirely exuvial, and are either thrown off by the constitutional power alone, or worn away by friction; sometimes, as nails, they are in a state of constant growth and destruction; sometimes, like feathers, they are periodically thrown off and replaced, whilst at other times, as in scales, they continue to grow till they attain their greatest size, when their production probably ceases entirely: in all which circumstances they exhibit great analogy to the different kinds of teeth.

### c. Nails, *Lamnæ*,

Are the horny plates which cover the upper surface of the extreme joints of the fingers and toes in the human subject, of the greater number of the monkey family, of the toes of some gnawing beasts which burrow, as the moles, also of the elephant; of the toes of gallinaceous birds, and of some of those belonging to the wading and web-footed orders, and also of some reptiles.

The nail is divided into tip, body, and root; the tip extends in the human subject beyond the extremity of the finger or toe, and does the same generally, though not always, to a greater or less extent in brutes, and is more or less angular or rounded. The body is all the smooth attached part between the tip and the white semilunar mark called *lunula*, situated at the bottom of the nail; it is more or less arched transversely and smooth on its upper surface, but exhibiting distinct indication of a longitudinal fibrous arrangement, which also curves somewhat towards the tip. Above the body is the root, the visible part of which is the white lunula, but a very considerable part is concealed by the overlapping replication of the skin, commonly called the *quick*. If the nail be separated from its slight connection with the skin by putrefaction or scalding, its under surface is found to consist of numerous delicate parallel longitudinal plates passing from the lunula to the tip, and received between corresponding plates of the hide which they cover and protect. These latter are merely rows of very delicate conical papillæ of the hide, from which they differ however in having neither perspiratory nor sebaceous apparatus. The root of the nail is received into a deep groove in the hide, which is deepened superficially by the replication of the skin (the quick). On removing the nail, and examining the surface of the finger or toe, the tegument is seen disposed in corresponding delicate parallel plates to those of the body of the nail; these are mutually received into each other, the principal object of which is doubtless that of connecting the nail more firmly to the finger or toe joint. This laminated appearance ceases opposite the lunula, the surface there being papillary. It is this part which is admitted to be the formative organ of the nail, but whether the laminated structure beyond assists in the process of thickening the nail by depositing fresh layers on the plates of nail immediately in contact with it, as supposed by Lauth, is not yet decided. With

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Zoology. regard to the skin, Weber considers that, after folding to form the quick, it is continued "beneath the nail, but is there softer and connected with the inner layer of the nail, which also becomes softer the deeper it is; or perhaps the skin lying beneath the nail is itself to be considered as actually forming the innermost layer of the nail;" it also "correspondingly overspreads the plates and depressions" there existing.* Gurlt says, in addition to this, that "the skin overspreads even the upper or free surface of the nail and wears off in its growth, so that it always has many irregular transverse stripes if the dried skin be not pared off."† These statements are doubtless both generally correct, but not in the way held by those writers. The apparatus by which nails, horns, hairs and feathers are formed, have one general model, consisting of a cylinder sunk into the soft parts below the surface of the body, and at the bottom of which is the true root or formative organ of the nail, hair, &c. This cylinder is lined throughout with a corresponding cylinder of hide, which reaches to the margin of the root, and within this the skin or cuticle descends, and, turning off from the interior of the cylinder, attains the surface of the nail or hair, and is there gradually lost. This upon the nail can certainly and without difficulty be proved; the only difficulty is that, instead of having the nail contained within a perfect cylinder, one side of the cylinder is sliced off obliquely upwards from near its bottom, leaving then only the groove or indent in which the root of the nail is received. Along the whole of this groove the formative organ is disposed transversely, and from it the nail itself springs. If the laminated plates also secrete the horny matter of the nail, an analogy can be found in the secreting organ of horns, and it is not to be supposed that either they or the root are covered with skin, which is rather, as before said, lost upon the nail itself: thus the skin, reaching the posterior margin of the groove in which the nail rests, folds upon itself and covers that edge, forming the *quick*, having done which it leaves the groove, and runs on to the back of the nail where it forms the "irregular transverse stripes" so well noted by Gurlt, as they are constantly, though unwittingly, observed by every one who is attentive to the appearance of his nails and carefully removes them; but if left they gradually rub off and are lost. The same transition of the skin from the finger to the nail occurs also at the projecting extremity of the latter; the skin passes from the bulbous end of the finger directly against the opposing surface of the nail immediately after its projection beyond its laminated connection with the tegument; but as it is protected from friction by the overlapping nail, it is not so readily rubbed off as near the quick, and therefore not unfrequently in dirty persons, especially beneath the tips of the great toe nails, masses of this skin are observed like small shreds of dirty horn.

The substance of the nail is at first secreted in a fluid form like the skin or cuticle, and gradually hardens as it grows, thickens, and is exposed to the air; its longitudinal dimensions are increased by the excretion of the root, and its thickness it may be presumed by the laminated root, as it may be called. It grows continually, and wears off or is broken off when it reaches far beyond the finger tip.

* See Weber, *loc. cit.* p. 194.

† See in Meckel, *Archiv* 1836, p. 264.

Vessels, the nail itself has none; neither nerves. Its formative organ is, however, very largely provided with them, and the density of the nail is sufficient to transmit exceedingly delicate impressions, and therefore we often employ the nail to detect irregularities which are not distinguishable by the highly sensible papillæ of the finger end.

### *d.* Claws, *Falculæ.*

The claws furnished to predacious beasts and birds are formed in the same manner as nails, but as to these animals they are most important organs, the glandular structure by which they are secreted is placed in a deep bony groove on the upper and lateral surface of the last joint of each toe, a sort of bony quick overlapping the root of the nail itself, which is thus also strengthened against dislocation; the cuticular quick is also largely developed. Upon the curving and sharpened form of the nail joint depends the form of the claw to which it corresponds; but its extent beyond the tip and its extreme sharpness depend in beasts on a peculiar construction of the extremity of the toe by means of which the claw joint, except when in use, always stands erect, so that the tip of the claw is not worn away by friction against the ground. Upon the under hollowed surface of the tip of the claw the shreddy collection of cuticle is always seen, and is got rid of only as the tip wears slowly away.

### *e.* Hoofs, *Ungulæ.*

Some animals, as the horse and its congeners, have each limb supported by a single toe inclosed before and on the sides with a horny covering called the Hoof, into which it is received like a foot into a slipper, hence they are called *soliped*, or *single toed*, or *single-hoofed beasts*: but others, which have in reality only a single toe, are distinguished by having both it and its horny covering cleft vertically into two portions, and hence are called *bisulcous* or *cleft-hoofed beasts*; such are all ruminant animals (except the family of camels), and also all the family of swine. The hoofed marsupial animals have the extremities of their toes covered with very simple hoofs, which are merely a mould of the toe itself. The general structure of the hoof is the same in all hoofed animals, and of these the hoof of the horse, being most fully developed, affords the most convenient subject for description.

The shape of the hoof is that of a truncated cone, of which the base is cut off obliquely, so that it does not stand upright, and a large segment, about a fifth of its whole circumference, is deficient behind, where the sides of the hoof terminate in the *heels* so called. The front and sides of the hoof are called its *walls*, which are hard and smooth externally, but exhibit a fibrous arrangement; the upper edge, somewhat swelling, soft, and whitish, is called the *coronet*, and is seen forming a whitish band just beneath the termination of the hairy covering of the hide; the lower part, which rests on the ground, is called the *base*, and the front of this is the *toe*, and its hinder ends the *heels*. The under part of the hoof which is contained within the base of the hoof, and connected with it, is called the *sole*, and is divided into the *sole proper*, which ascends from the base and forms a hollow looking downwards, and the *frog*, which consists of two horny ridges united at an angle in front, and thence diverging as they recede to terminate in the heels, where both sole and walls of the hoof are bounded posteriorly by the hairy skin; between

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the two legs of the frog is a deep pit, called its *cleft*, and on their outer sides are gutter-like hollows, against which the sole proper abuts, and these are bounded behind by an S-shaped short ridge which passes from the middle of the frog on each side to the hinder extremities of the heels of the vertical part of the hoof, and called the *bars*. When the hoof has been removed from the foot by putrefaction or by scalding, its interior exhibits some very interesting circumstances in reference to the connection of nails as well as hoofs to the subjacent soft parts. The parallel plates seen on the under surface of the nail have here their analogue in the vertical plates, so numerous as to have been counted to five hundred by Bracey Clark, which descend from the coronet to the sole, where they terminate. The inside of the coronet, which is hollowed correspondently with its external swelling, is perforated with numerous holes, the mouths "of longitudinal hollow threads or hairs matted and strongly glued together," of which, according to Clark, "the wall of the hoof if decomposed will be found to consist." Gurlt's observations are also to the same effect: he says, "these tubes are, at their upper end, wide and funnel-shaped, and connected by a formless horny tissue composed of point-like corpuscules." He further says, that "the tubes consist of numerous concentric and rather wavy rings, and are hollow to their lower extremity, as a transverse section clearly shows the light through them, and it is therefore probable that, like the hair tubes, they absorb moisture from below."* This tubular structure, however, according to the same writer, is not extended into the parallel plates, which are solid. The upper surface of the sole and frog is also full of similar small apertures, the upper ends of tubes.

The horny hoof, or rather its interior, is merely a mould of the organ by which it is produced, and which, from its high organization, has been usually called the *sensible* hoof, and its several parts the *sensible* coronet, plates, sole, frog, and bars. The sensible hoof contains within it the large flat coffin bone, or last joint of the toe, with the shuttle bone behind, and above it the lesser pastern or coronet bone, which is partially included within the coronet of the hoof. The sensible hoof is not, however, at all parts in immediate contact with these bones; it is so indeed on the front and sides where the plates exist, but between it and the whole frog, and more especially at the heels of the frog, there is a very large mass of dense fibrous tissue intermingled with bags of fat, which by their yielding prevent the sensible frog being injured every time the foot descends to the ground. The true or glandular or sensible coronet resembles a half cylinder bound round the foot immediately below the termination of the hair: upon it are seen numerous papillæ, according to Gurlt, of three or four lines in length, which descend through the apertures of the horny coronet into the tubes penetrating the wall of the hoof, the horny matter of which they secrete. From below the coronet, and descending to the base of the foot, numerous delicate thin plates, in appearance resembling the leaves of a not very closely shut book, pass down; these are the sensible plates, and are received between the corresponding plates of the horny hoof. The surface of the sensible sole, frog, and bars, and their neighbouring cavities, are covered with papillæ similar to but much shorter than those on the coronet, and are received into the corresponding apertures of the horny sole, which is considerably thinner than the walls of the hoof, with which it joins, as before said, at the circumference of its base. By means of these structures then is the horny hoof produced, and its continual destruction by use constantly repaired. It does not seem necessary to consider the papillæ of the coronet and sole as a distinct and different structure from that of the plates; their product is the same, horn; their arrangement only is different, though the object is the same, to connect the hoof and its secreting organ most firmly together, and at the same time to produce an immense apparatus of springs, which prevent the jarring of the body under common circumstances every time the foot is set to the ground, and also in the more violent exercise of trotting, cantering, and galloping, in which the foot strikes the earth rapidly and violently, to prevent the foot bones being smashed to pieces, as they certainly would be without such arrangement. It is almost needless to observe, that the growth of the hoof is going on in two directions at the same time, viz. that it grows from above downwards from the sensible coronet, and that it grows in rays from within outwards from the plates; and that the toe, which is often an inch or an inch and a half thick, is not formed by an additional number of hairy tubes or longitudinal fibres, which even they may really be, but by the increased quantity of horn produced by the lower ends of the sensible plates.

The cleft hoof of cattle and swine is precisely similar, except in the hoof being divided vertically from before to behind into two halves, and in the sole being regularly hollowed from the circumference inwards, and also in having neither frog nor bars.

The hooflets inclosing the little trigonal bones at the back of the fetlocks of cattle, and which are analogous to the rudimental inner and outer toes of swine, the extremities of which are also hoofed, are little more than models of the bones they inclose, their upper surface however is somewhat smoother than the under. The horny covering of the large hind toe of the kangaroos is also of this kind, and differs little except in projecting further beyond the tip of the bone, and being of a more pointed form.

### *f.* Horns, *Cornua*—Beaks, *Rostra*—Spurs, *Calcaria*.

Independent of the deciduous horns of deer, or solid horned beasts, two other kinds of horns are found. The first and most common kind belong to ruminant animals, and with this division may be considered the beaks and spurs of birds and the beaks of chelonian reptiles; the second exists only in the rhinoceros, and perhaps the hairy tufts on the horns of the cameleopard may be not improperly mentioned with them. In the first kind the horn has a bony support, in the second it has none.

*Horns supported by bony processes.*—From above the temples in ruminant bisulcous animals spring up a pair of bony processes, which in different individuals exhibit great variety of size and shape, and are overspread and concealed by a horny covering. This horny covering at its base, and for some distance upwards, corresponds to the bony *core*, as the process is called; but having reached the tip of the core, it soon becomes simply solid horn, and makes more or less curves, varying in direction according to the original arrangement of its fibres at the base, which is always of great breadth, from whence the horn gradually tapers to its tip. The structure of the horn is fibrous, and the fibres take the direction of the twist of the horn. It has great resemblance to the structure of the hoof, and has

* See in Meckel, *Archiv* 1836, p. 269.

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by many been considered as having the same matted hairy composition which the walls of the hoof have. This opinion has been thought to be confirmed by the circle of vertical hairs surrounding the root of the bony core, and within which the root of the horn commences, soft, thin, and white, like the horny coronet of the hoof, but gradually becoming thicker, denser, and darker coloured as it gets at greater distance from the root. When the horn is removed by putrefaction or scalding from the bony core, the latter process is seen covered with a very vascular membrane, which is doubtless the modified hide, but it does not exhibit any of the laminated structure seen in the sensible hoof; around the root however it has greater fulness, and somewhat resembles the sensible coronet. It may be presumed that the whole membranous core secretes horn as well as the base, for it is throughout extremely vascular, and the indents of the vessels are seen both in the bony core and on the horny sheath. It probably increases the thickness of the horny walls by interposing additional horny matter, both circularly and longitudinally; and it would also seem probable that both longitudinal and circular fibres become in some peculiar manner contracted and more closely approximated in proportion as they get farther from the root, and hence, above the core, all appearance of cavity ceases, and the horny structure is very dense.

The growth of these horns, at least their growth from the root, does not appear to take place constantly, but annually; and at the conclusion of each growth a sort of irregular ring surrounds the base of the horn just above where the hairy skin ceases: hence the number of these rings are held by graziers to indicate the animal's age.

The beaks of birds, the horny protuberances on their heads, and the spurs which often are found on their legs a little above the feet, and occasionally also on their wings, have nearly the same arrangement, the horny coverings of such parts being models of the parts they cover. The density of the horny covering of the beaks is however extremely various; is perhaps most dense in the beaks of woodpeckers and parrots, whilst in other birds, to which the beak is an organ of touch, as in such birds as hunt for their food in moist earth, their covering can scarcely be called horny, but is rather a soft and highly sensible hide with a thin covering of skin, as in the duck, woodcock, &c. In many birds the root of the beak is overlapped with a band of skin called the cere, which corresponds to the quick of nails and claws.

*Horns without bony processes.*—The nasal horn of the rhinoceros has no bony core; a small boss indeed does spring up on the front of the nose bones, but it only rises up a very short distance into the shallow, hollow base of the horn itself, which merely consists of a mass of hollow fibres, supposed to be hairs, and becoming more closely consolidated as they proceed to the tip of the horn. Cuvier states, that "at their base these horns present on their external surface an infinity of coarse hairs which seem to separate from the mass and render the surface as rough to the touch as a brush. If the horn be sawn transversely, and examined with a magnifying glass, an infinite number of pores are observed, which indicate the spaces resulting from the union of the agglutinated hairs. If the section be made longitudinally, numerous longitudinal and parallel grooves exhibit the same structure."* Beyond this no further account of the structure of the rhinoceros horn is given, but it is most probable that the pores held by Cuvier to be formed by the approximation of the hairs were rather sections of the cylinders of the hairs themselves.



The horns of the cameleopard are a pair of short, straight bony processes resting on the forehead, for they are formed entirely independent of the skull, which completely ossifies before union takes place, and exhibits a pair of slightly elevated swellings, upon which the expanded hollow bases of the horns rest. Whether the processes remain distinct through life is doubtful, but perhaps they do, as the surface of the skull is so perfectly smooth that it leads to the supposition of an union somewhat similar to that between the roots of the teeth and the corresponding alveolar cavities. The whole surface of these horns is covered with the common hairy covering of the body, but their blunt ends are surmounted each with a tuft of short coarse bristly hair somewhat matted together at the base.

If then it be held that hoofs and horns are merely masses of hairs agglutinated together, the hoofs of the soliped animals, the hoofs and horns of bisulcous beasts, and the beaks of birds exhibit them in their most closely agglutinated form; and the nose horn of the rhinoceros, assuming a more loose texture, gradually leads through the distinctly matted hairy tufts of the cameleopard to true and distinct hair.

### g. Hairs, *Capilli*.

The parts composing a Hair are, the stem, which appears on the external surface of the body, and its root, which penetrates more or less deeply beneath. To these, which form the hair proper, must be added the sheath containing the root, and which, excepting Malpighi, has been considered by all the older writers on the subject, and by some among the moderns, as Gualtier and Beclard, as part of the root or bulb, which term they apply to the whole hidden part of the hair. Malpighi is however now more generally and more properly followed.

The Hair-Follicle, Sheath or Capsule, *follicula seu capsula pili*, is the little membranous canal by which the hair is invested till it has passed upon the surface of the skin. Malpighi (taking as an example a hair from the lower lip of a horse or ass) describes it as "an oval and violet coloured follicle, consisting of a thick tunic, which he has sometimes thought to be reflected within the hide, and not unfrequently seen possessing circular fibres."* Haller, following the observations of Chirac, speaks of it as part of the bulb, and says it is "a shining, tough sheath divisible into layers, thinning and becoming reddish and contracted towards the skin, where it terminates in an aperture of that texture."† He also observes that, "in man, the bulb is of similar colour to the skin, so that it can scarcely be divided into two tunics; and that some good authorities consider it only as a single sheath." Bichat described it as "a kind of little membranous canal, of the nature of which he was entirely ignorant, but the transparent walls of which allow the hair to be distinctly seen. This little cylindrical canal accompanies the hair to a corresponding pore in the skin, into which it insinuates itself, passes through and extending to the epi-

* See his *Leçons d'Anatomie Comparée*, vol. ii. p. 613.

* See his *Opera Posthuma*, p. 93.

† See *Elementa Physiologiæ*, vol. v. p. 34.

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Zoology. dermis, is confounded with the tissue of that membrane, and can be followed no further."* He also says, that "there is no connection between the hair and the inner surface of this little canal, except at the swelling base of the former, the point at which it seems to receive its nourishment." Gualtier considers it as continuous with the hide, but Eble holds it to be, on the whiskers or bristles on the muzzle of the ox, from which he draws his description, "a membrane about a quarter of a line thick, of a homogeneous tough tissue, which bears the stamp of a membrane *sui generis*."† He denies Gualtier's assertion, that it is a process of the hide, and states that both its surfaces when fresh are glossy, and resemble fibrous membrane; that it forms a bag, having a large opening above and several smaller ones below. The opinion of Heusinger corresponds with that of Bichat in regard to the sheath; for he says he "can distinguish in it nothing but a simple, thin, transparent membrane, smooth on both its inner and outer surface, except at the bottom, where the root of the hair is so attached, that the outer membrane of its root seems to subside completely into the membrane of the bag, and if the hair be here separated from it, there remains a little pulpy very vascular knob which lies in the cavity of the root of the hair, but is only distinguished by its red colour from the other structures of which the root of the hair is formed."‡ In Gurlt's description it is stated, "the hair capsules are doubtless produced by an engulphing of the cuticle, and this can easily be proved, in addition to the reasons already advanced, (viz. by the colour of the cuticle, in such animals as have coloured cuticle, extending into them, which he had previously noticed as common to the hair capsules and the sebaceous ducts,) by macerating the skin of a fœtus till the cuticle is distinctly separated: there remain then the hair capsules with the hair germs attached to the inner surface, but if the hairs have elongated, the capsule usually tears, as always happens with the perspiratory ducts."§ With regard to this observation of Gurlt's, however, it will be readily perceived, that the only addition to our knowledge of the structure of the hair capsule he has made is, that the cuticle dips into its upper orifice, and is gradually attenuated and lost upon it in precisely the same way as the cuticle overlaps the roots of nails, and terminates by forming the so called *quick*. The substance of these various opinions may be briefly summed up by stating, that the hair follicle consists of a membranous bag of peculiar texture, into the open mouth of which a lip of skin is received. The length of the hair follicle varies according to its situation, being from one to two or three lines, and sometimes even four or five, according to Eble.‖ Sometimes it is implanted only in the hide, but at other times passes through, and has its base resting in the subjacent cellular tissue. It is by some described as cylindrical, and by others as oval, and at its lower part is wider than above. The follicle is not implanted perpendicular to the surface of the body, but in most instances obliquely, so that in the human subject the hair is generally directed downwards, but in the bodies of brutes in the direction of their longitudinal axes, whilst on their limbs it depends towards the ground; exceptions however occur in both: thus the eyebrows in the human subject, the whiskers, the peculiar ruffs and the manes in brutes, in which the hair follicles are so placed that, as the hairs protrude from them, they assume a horizontal, oblique, or vertical position. Zoology.

Malpighi states that within the follicle there is a space separating it from the bulb of the hair, which is filled with blood, and when the follicle is slit up the blood escapes, and leaves it flaccid instead of being turgid as it had been previously; and that in the whiskers of the ox he had observed "some transverse and horizontal appendages, ligaments as it were, extending from the bulbous root of the hair to the tunic of the follicle."* The presence of any fluid in the follicle is totally denied by Bichat. But Eble speaks of "a somewhat transparent, brawn-like, diversely red-coloured body," as found within the follicle of an ox whisker, with which it is connected by innumerable very fine transverse threads, and on its division a very fluid blood exudes, by the escape of which the whole part assumes a yellowish-white appearance."† This confirmation of Malpighi's observation is extremely interesting, and is one of the numerous proofs which might easily be adduced of his accuracy.

In human hair, Eble was not, however, able to discover this brawny structure, or anything analogous to it, but he thinks it probable that it exists and is connected with the hair itself.

The Hair-Root, or Bulb, *radix seu bulbus pili*, is the organ by which the stem of the hair is secreted, and stands in the same relation to it as the hide does to the skin, the stem and the skin being both unvascular parts, at least when they are perfectly produced, if not indeed from the very first. Malpighi beautifully and accurately observes, "the little plant of hair is seen in the follicle, implanted as it were in a flower-pot, and vegetating from its root or bulb, an oval body of an ashy colour and softish substance, the nature of which I cannot by my senses ascertain. I may, however, be permitted, without disparity of reason, to conjecture that this medium furnishes to the inclosed little plant the particles separated from the blood contained (in the hair follicle), just as it occurs in bulbous plants."‡ The form of the hair-root is flask-like, or bulbous, and of a more or less cylindrical or globular form, according to its situation in different parts of the body, and this variety of form may be not inaptly exemplified by the change from the cylindrical to the nearly globular form which the bulb of an onion presents in the course of its growth prior to its globular form being converted into its fully developed, oblate-spheroidal shape. Thus in the smaller hairs of the trunk, the hair-root is more lengthy and cylindrical, and scarcely more swelling than the lower end of the stem itself, whilst, on the other hand, the hair-roots of the head, eyebrows, breast, and armpits are more flesh-like or globular. Its consistence is fleshy and its colour reddish, greyish, or blackish, corresponding with that of the stem itself, but always paler than it. When first drawn from the follicle, the hair-root is glossy and slippery from the moisture contained in that cavity, but this soon evaporates and the glossiness disappears. Malpighi states that "at its first origin the plantule (germ) of the hair consists of a little softish and black head, which seems perforated;" and shortly after observes "it is surrounded with a transparent bulb, black and mucous." It is therefore clear that he held the

* See his *Anatomie Générale*, vol. iv. p. 807.
† See his *Lehre von den Haaren*, vol. i. p. 65.
‡ See his *Histologie*, vol. i. p. 157.
§ See Gurlt in Meckel, *Archiv* for 1835, p. 412.
‖ See *Op. cit.* vol. ii. p. 8.

* See Malpighi, *Op. cit.* p. 93.
† See *Op. cit.* vol. i. p. 65.
‡ See *Op. cit.* p. 93.

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bulb or root of the hair to be composed of two parts, the second of which is "the exterior delicate membrane, soft at the base of the bulb, but above subsiding into the horny, cellular substance of the hair," mentioned by Heusinger, and to which Ehle has given the name of *cortical* or *outer substance* of the root; and if this be split down longitudinally, it is found filled with a pulpy substance of a conical form, which Gualtier calls the "*conoid body*," seemingly of a gelatinous and fleshy nature, red when the hairs are white and reddish-brown when they are black. This is called by Ehle the *medullary* substance of the root, and in the very centre of the mass he has found, in dark and specially in black hair, a little black nodule, of the nature of which he says he is ignorant. As, however, he states that the pulpy mass is lost in the soft interior of the stem, and as Heusinger had previously observed it subsiding into the cellular substance of the hair, it doubtless corresponds to, and is really "the little softish black head" described by Malpighi. Gurlt considers it to be "the proper matrix of the hair," its formation being effected by the bottom of the hair-follicle elevating itself. And he further states that himself, as well as Ehle, "have seen in the whiskers of newly-born cats, of which the vessels had been injected, this process penetrating into the root of the hair, and coloured with injection; he could not, however, distinguish any vessels, and it therefore seemed that the injection was freely poured out like extravasated blood." He also observes that "at the first production of the hair a soft granular mass springs up from the bottom of the hair follicle to the rudimental hair, but that when its formation is perfected, this mass disappears, and in its place are seen several processes like the fibrils of a root, which pass from the follicle to the hair-root."* This medullary substance is therefore to be considered in part as the organ forming the horny matter or cortical substance of the hair, and in part as that horny substance just poured out in its semi-fluid state, which gradually becomes hard and tough; and the analogy which exists between it and the hide with its recently formed semifluid cuticle or skin is very close, and rendered still more so, if the little black nodule contained within it be considered, as seems probable, to be the pigment which, rising up within the hair-stem as it overspreads the inner surface of the cuticle and colours it, also gives its peculiar hue to the hair.

As to the vessels of the hair-follicle and root, there has been much difference of opinion. Hildebrandt denies the existence of any vessels in the hair; but, on the contrary, Weber says the bulb, that is, Gualtier's *conoid body*, is very vascular; and the latter writer states he has seen the vessels "entering the neck of the capsule (or narrow orifice of the follicle) close to its cutaneous extremity by one, or sometimes even two little orifices by the side of that through which the hair passes. After a longer or shorter course they expand by numerous ramifications between the capsula and the sheath, (the two layers of the follicle in brutes,) producing frequent communications between them, and finally are distributed to the generating body which enters the hair"† (the conoid body, or true root). Ehle also states that he has "distinctly traced blood vessels into the capsule (follicle), and found the larger arteries so divided that the greater number of them stretch to the point where the hair is implanted, and the capsule itself provided with numerous small vessels, in part regularly, and particularly from the base up to the orifice, and partly from the sides." In some hairs of the beard he discovered only a few and very irregular fine vessels; but in the whiskers of a cat he found "not merely the outer layer of the follicle, but also the so-called conoid body perfectly injected, the inner surface of which, towards the hair, had a much greater number of delicate vessels than the outer surface. But great indeed was my delight, when I saw, instead of the hair-germ, the whole cavity of the root of the hair swelling with injection, and so had undeniable proof before me that the root is in direct connection with the vessels of the capsule, and that the so called conoid body and hair-germ are none other than a secretion from the exhaling hair-vessels, which are found both on the inner walls of the follicle, as well also as at the bottom of the root."* Besides it may be noticed that, in the beautiful anatomical plates of Mascagni, the root of a human fœtal hair is engraved surrounded with a delicate network of absorbing as well as blood vessels.

Nerves, although denied by Hildebrandt, have been traced by Bichat and others into the hair-follicle, and in the whisker of a cat it is no difficult task to trace a minute branch of the supraorbitar nerve penetrating its base.

The Hair-shaft, Stem or Cylinder, *caulis, filamentum, truncus pili*, is that part commonly called the *hair*. It commences immediately above the root, and its origin is indicated by a contraction called the neck. It has been a much disputed question whether the shaft is hollow or solid. Malpighi says that "a washing of the pendent hairs from the tail and neck of horses and mules shows the shaft to be pipelike; in these hairs two substances are found, an outer one which forms the pipelike body, and an inner, as it were marrow, with which the sinus or duct is filled throughout its whole length."† Rudolphi and Weber, on the contrary, deny that the hair contains any cavity, and the latter observes "only indeed as an exception, and in some large beard-hairs have I noticed two substances, an inner white and an outer dusky substance. In most hairs there is but one homogeneous substance, in which neither distinction of cortical or medullary substance, nor shade of colour, can be distinguished."‡ It is, however, generally held that the shaft of the hair does consist of two parts. Bichat and Meckel both speak of an external covering, which has all the properties of skin or cuticle, and has a whitish colour, whatever be the colour of the hair, depending on that of the marrow or inner substance, which the latter anatomist states is made up of several, about ten, fibrils, which he supposes may be vessels, of a dusky colour, having their interstices filled up with a sort of fluid. This account differs little from that of Whithof, who speaks of a viscid humour contained in cells within the sheath; which is also the opinion of Heusinger, who states that "if a very pale blond hair be put under a microscope, it appears transparent throughout almost its whole breadth, the edge, or so-called rind, being only a little more dusky (thick); there is nothing, however, like a distinct cavity, but the whole hair-cylinder is filled with a true cellular tissue similar to that of plants, which extends nearly to the outer edge"‡ He does not, however, consider the

* See Gurlt in Meckel's *Archiv* 1836, p. 272. † See *Op. cit.* p. 25.

* See *Op. cit.* vol. ii. p. 18. † See *Op. cit.* p. 93.

‡ See Weber, *Allgemeine Anatomie*, p. 197.

‡ See *Op. cit.* vol. i. p. 155.



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cellular structure to be confined to the interior of the hair, but, from a presumed analogy with the hair of the roebuck, he holds the entire structure of the hair-shaft to be cellular, and says that "on a transverse section (of the roe's hair) around the whole circumference of the shaft is seen a row of smaller cortical cells, which bound the somewhat larger medullary cells."* This cellular structure of the outer layer of the hair is denied by Eble and by Gurlt, the latter of whom considers it distinctly fibrous, whilst the former says, "it is only a layer of horny tissue in all respects resembling the cuticle, except in its toughness, thickness, and indestructibility by maceration, boiling, or chemical agents;"† facts which had been previously noted by Bichat. Considering then that the exterior surface or wall of the hair is horny and very closely resembling skin, it has been asserted by Ruysch, Kauuw and Whithof, as quoted by Haller, that "the hair, so soon as it reaches the epidermis, does not really perforate it, but protrudes it before it in shape of a funnel, so that it provides from the cuticle itself its own sheath connected by an inseparable tissue to the second sheath which originates from the bulb."‡ Lauth also says that "the hair by its base is in close connection with the epidermis (skin), which is reflected within the bulb and continued uninterruptedly with the hair so as to form a little sheath, which envelopes it from the base to the very point where it leaves the skin. Thus viewed, the hair is actually but an integral portion of the epidermis developed towards the exterior."§ Such, however, is not the case, for Weber says "the skin does not rise up as a sheath; but when the hair cannot find a passage through, it is elevated in form of a little hillock, in which the hair lies curled up, as Leeuwenhoek had already, and Weber himself frequently, observed in his own arm."‖ On the approach to puberty these little elevations may be commonly observed, but so soon as the hair finds its way, or bursts through the skin, they gradually and at last entirely disappear. Gurlt also has shown, as already mentioned, that the cuticle only lines the upper part of the hair-follicle, upon which it is gradually lost, and must therefore leave an opening through which the shaft of the hair passes freely. And Eble remarks that if the follicle of an ox whisker be split down lengthways, and the whisker be drawn gently upwards, it will be seen where it penetrates the skin, and below in the hide will be found a little roundish cavity in which the hair lies quite loose, whilst its attachment to the follicle is about a quarter of a line below the aperture in the cuticle.¶ It must therefore be presumed that the outer horny covering of the hair-shaft is the product of its own peculiar gland, and that it has no connection with the skin. Some writers have said that the surface of the shaft is covered with a sort of beard like that of corn running from below upwards, and that it is by means of this that the hairs cling together. Fourcroy states that he has observed this on rubbing a hair between the fingers. Bichat and Heusinger deny their existence, but as it is well known that the hair often splits at its extremity, it is not very difficult to understand that parts of its sides may occasionally shred off in the same way, as is also frequently seen in the production of hagnails upon the cuticle of the fingers.

* See *Op. cit.* vol. i. p. 186. † See Eble, *loc. cit.* vol. ii. p. 23.
‡ See Haller, *Op. cit.* vol. v. p. 35.
§ See *Nouveau Manuel de l'Anatomiste*, p. 302.
‖ See Weber, *loc. cit.* p. 204. ¶ See *Op. cit.* vol. ii. p. 21.

As to the interior or marrow of the hair-shaft, little more need be said than what has been already mentioned. Whithof thought the hair hollow; that the medulla was partly moist or fluid and partly solid; that the former was viscid, capable of being drawn into threads, and containing many little globules or bladders on which the colour of the hair depended; whilst the latter was made up of very delicate glossy fibres, arising from the interior of the root, interweaving with each other, and not merely forming part of the marrow, but also by their threads connecting the several tubes of the hair. Chirac states that in the hair of brutes, the medulla consists of a string of little bladders, which form a kind of pith similar to that of feathers. Meckel's opinion is that it is made up of a bundle of threads, probably vessels, in the interstices of which is a fluid matter, which, however, Heusinger holds is contained in cells. Eble has been extremely successful in the microscopic examination of human hair, of which the following is a brief account. If a chesnut-brown hair be placed under a good microscope, at the extremity of its root are seen some short threads which are the remnants of torn vessels and nerves; the root itself appears half filled below with a black pigment and opaque, but the upper half is transparent and exhibits distinctly the two substances previously described, of which each runs directly into the corresponding part of the hair-shaft. The inner occupies half the diameter of the shaft, springing up as a light brown streak from the bottom of the root, or rather from its lowest black half, and at its commencement divided by a short, pale-coloured indentation into three or four unequal parts, as if arising by three or four tubular roots, which in the upper half of the bulb or the beginning of the shaft unite and form a single light brown stripe, which runs almost to the very tip of the shaft, and has the cortical substance of proportional thickness. The texture of this stripe varies in hairs from different parts; but the very finest hairs, even of little children and delicate women, all at first view lead to the idea of the inner brown stripe being a hollow tube in which some coloured substance, like fine oil, ascends or is contained. This longitudinal stripe is in all hairs divided by transverse plates, the distance or thickness of which varies, not only in different hairs but in every single hair. Very frequently, though not in all hairs, nor in every part of the hair-shaft, are seen here and there dark-coloured patches of unequal length and breadth, in this shining stripe, at first sight homogeneous, and therefore not interrupted by transverse partitions, so that it seems as if a semifluid matter remained, as it were, sticking and hanging in the interspaces of the step-like, closely-lying transverse plates; but as these patches were found in old hair as well as in that which had been recently plucked, it could not depend on the existence of fluid. It is however remarkable that these spots were found only in the middle and never on the sides of the hair. The oily-like fluid said to circulate or to be contained in the interior of the hair, Eble could never discover, and he agrees with Bichat that he is totally ignorant of the nature of this interior substance. He however admits that the dusky stripes in the middle of the inner substance of the root very much incline him to consider them with Gualtier, as elongations analogous with hair-germ; for if a hair be split longitudinally, the pulpy body which fills the innermost part of the cavity of the root is seen springing up, and thus distinctly elongating

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itself into that substance of the hair-shaft which is called the marrow.*

As to the shape of the hair-shaft, it has been described by different writers as round, oval, triangular, and quadrangular, and some have considered each hair to be a hollow open tube. Malpighi describes them as roundish in some cases and square in others; and Leeuwenhoek very epigrammatically *quot crines, tot figuræ*, in which opinion Eble coincides on comparing hair from different parts of the body. Weber has, however, recently stated that human hair is seldom round, but mostly somewhat flattened, so that its section appears rather oval or kidney shaped. Generally speaking the root is by far the thickest part of the hair, and where it terminates the contracted neck appears, whence the shaft which first swells a little, gradually tapers to its almost imperceptible tip. But even the form of the root varies not only in different animals but in different parts of the same animal, in some being more globular, in others more oval, whilst not unfrequently it is but little larger than the base of the hair-shaft itself. The diameter of the hair has been variously stated; this also depends on the part from whence it has been plucked. Leeuwenhoek speaks of it as [illegible] of an English inch, which, according to the observations of Weber, seems to be a fair average in the human subject. Rosenmüller has given the following comparative statement as to age:

| | | |
|---|---|---|
| Beard-hair } in an adult | from [illegible] to [illegible] of a Paris inch. |
| Head-hair } in an adult | " [illegible] " [illegible] | " |
| Ditto of a little child, from about | [illegible] " [illegible] | " |

Woolly hair from the body of a fœtus, about [illegible] of an inch.

As to its difference in several of the different human races, Weber gives the following statement:

| | Paris inch wide. | Paris inch thick. |
|---|---|---|
| Head hair of his own, not curly | [illegible] | [illegible] |
| Of a Mulatto which was curly but not woolly . . . . . . | [illegible] | [illegible] |
| Of a Senegambia negro which was woolly . . . . . . | [illegible] | [illegible] |
| Of a negress from the borders of Nubia, in which it was wavy | [illegible] | [illegible] |

He also remarks that the curliness of hair seems to depend on its flatness, for the flatter it is the more it curls.

With regard to the number of hairs contained within surfaces of similar size on different parts of the body, the observations of Whithof and Jahn are curious and nearly agree. The latter counted in a very hairy man, aged twenty-eight, the number of hairs in a given space on the following parts:

| | | In the same person four years after, he having been married three years, the numbers were— |
|---|---|---|
| On the top of the head . . | 321 . . . . | 292 |
| " back . . . . | 242 . . . . | 230 |
| " front . . . . | 238 . . . . | 210 |
| " chin . . . . | 52 . . . . | 59 |
| " pubes . . . . | 45 . . . . | 50 |
| " fore arm . . . . | 31 . . . . | 30 |
| " little metacarpal bone | 20 . . . . | 17 |
| " front of the thigh . | 21 . . . . | 12 |

* See Eble, *loc. cit.* vol. ii. p. 28.

Both, also, ascertained that light hair was thinner than dark, and Whithof counted the number, and found that one-fourth of a square inch contained 147 black, 162 brown, and 182 blond hairs.

The length of the hair varies very considerably in different parts of the body; that of the head is ordinarily the longest, and it is of greater length behind than in front. The hair of the male beard is next in length, and often becomes astonishingly long. Eble, amongst other instances which he has collected from various sources, mentions the two following:—one a full-length painting at the Prince's court at Eidam, of a carpenter who, whilst at work, was obliged to carry his beard in a bag, as when let drop it not only touched the ground but also turning up again reached his waist, and measured nine feet; the other that of the Burgomaster Hans Steininger, who, having forgotten to fold up his beard, which dragged beneath his feet, was thrown down by it in ascending the steps of the council-chamber at Brunn, and lost his life in consequence. Upon the breast the hair sometimes acquires great length, as in the instance of the fakir mentioned in Fry's *Travels*, p. 102, in which it was four ells long; and Eble speaks of a young woman whose nipples were closely surrounded with hair an inch long. The pubic hair also not unfrequently grows very long, and in several instances has reached the knees. Sometimes the hair of the whole surface of the human body grows inordinately, and histories of such hairy persons are numerous in the older writers. Ruggieri published in 1815 the account of a female aged twenty-seven, who was covered like a poodle dog from the breast and shoulders to the knees with black, soft, woolly hair. And on the last embassy to the Burmese court, in 1829, a man was seen at Ava completely hairy from head to foot. His face, together with the ears and nose, were covered thickly with hair not less than eight inches long, but on his breast and shoulders it was not more than four or five inches. He was a native of Lao, in the snowy country on the upper part of the Mataban River, and had two daughters, one of whom resembled her pretty mother, but the other was like her father, except that her hair was white and blond, whilst his was brown and black.

The strength of hair depends upon its length, thickness and flexibility. Muschenbroeck found that a human hair, about fifty-seven times thicker than a silkworm thread, would hold up 2069 grs.; and a horse-hair seven times thicker, about 7970 grs. And from the comparative experiments of Robinson it appears that a single hair from the head of a boy of eight years will support 7812; of a man of twenty two, 14,285; of a man of fifty-seven, 22,222.* Hence it appears that hair is very strong, but it is also extensile and elastic, Weber says, like caoutchouc; and according to his and his brother's experiments, a hair of ten inches long (Paris measure) can be stretched, without breaking, to near a third of its length; but if it be only stretched one-fifth, it so nearly reverts to its original condition that it is found not to have gained more than one-seventeenth by the process.

The hair on different parts of the body varies materially even in the same person, of which, excepting the beard, the soft, downy hair of the face is well contrasted with the stiff eyebrows, and the still more rigid hair within the nostrils, which have so almost bristly cha-

* See his *Essays on Natural Œconomy*, p. 320.



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racter. The more hairy parts of the body are too well known to require annmeration, but it may be observed that it grows most luxuriantly where the perspiration is most free, and that all the external orifices are specially protected by it, the hairs in the nostrils being most bristly, whilst those in the external ear-passages are most silky, but in much greater number. It may also be noted that generally the female hair is of more delicate texture than the male, and is consequently softer, smoother, and more flexible.

The straightness or curliness of hair Malpighi thinks is dependent on the quantity of fluid contained in its tubes; thus, "whenever the tubes are equally filled with the contained juice, they (the hairs) are straight; but when only a lateral portion of the tubes swells with the juice, and the opposite side is left empty, obliquity necessarily ensues."* Glisson, however, considered these characters of hair rather as resulting from the resistance it meets with in its passage through the tegument, which, if it contain much and soft parenchyma, readily allows the hair to penetrate it, and therefore it is straight; but if the parenchyma be dry or thin, and the tegument itself very tense, and the aperture by which the hair protrudes narrow and compressed, its passage is interfered with and the hair curves to one side or other. Baster's opinion is very similar to this, as he considers the curliness of the negro's hair to depend on the difficulty it has to penetrate the so-called mucous body, which he says in the negro is much more tenacious and tough than in other races. Hatchett holds that the curling depends on the smaller quantity of gelatine contained in such hair.

As to colour, the hair varies in different persons from the most glistening silvery white to raven black: the principal colours are white, blond, red, brown, and black, with their intermediate varieties. The colour of the hair is usually in relation to that of the complexion, and both are generally darkest where the climate is hottest; exceptions, however, occur in the people inhabiting high northern latitudes, the Esquimaux for instance, mentioned by Captain Ross as having the skin dirty copper-colour and the hair black. And sometimes, indeed not unfrequently, persons are seen among ourselves with dark hair and pale complexions, whilst, on the contrary, blond hair and fair complexions are occasionally accompanied with dark eyebrows, and considered very beautiful. The cause of the colour of the hair Malpighi supposes to be the fluid contained in the tubes, which, according to its quantity or transparency, more or less permits the passage of the light, or reflecting it produces difference of colour. Some modern chemists, however, as Vauquelin, think that the colouring principle is in the oil of the hair. On the contrary Berzelius doubts the existence of oil, and thinks that albumen and the colouring matter of the blood colour the hair; whilst Rodolphi supposes that the less or greater quantity of horny matter in the hair is sufficient to account for its variety. Gualtier considers that the hair-root or bulb is the organ of the colouring matter; for he observes, the skin is always coloured where there are hairs, whilst the palms of the hands and soles of the feet, on which no hairs exist, are colourless; and that the colouring matter is in different proportions in the hair and in the integuments, for, in the long hair of white persons, especially women, it is almost entirely deposited; whilst on the contrary, in the woolly, short-haired negro it is wholly spread upon the surface of the hide.*

* See Malpighi, *loc. cit.* p. 94.

The difference in the texture, and also in the colour of hair, is so regular that Blumenbach has employed it as one of the characters distinguishing the four races into which he divides all the inhabitants of the earth: thus in the *Caucasian*, among which are included the greater number of the natives of Mid Europe, the hair is brown or nut-coloured, sometimes running into yellow and at other times deepening into black; it is also soft, plentiful, and wavy;—in the *Mongolian* and *American* races it is black, soft and sleek, and more thinly disposed;—in the *Malay*, soft, curly, thick, and plentiful, as in the South Sea islanders:—and in the *Æthiopian* it is curly and woolly and black.

The most complete chemical analyses of the hair are those of Vauquelin and of Jahn. Vauquelin found that hair boiled in water exposed to the air for several days seemed unaltered; the water, however, was impregnated with a little animal matter, detected by tincture of galls and other re-agents, and which also disposed the water to putrescence; but he did not pursue the inquiry further. In Papin's digester, under a moderate degree of heat, the hair dissolved into a mucous-like fluid, by which ammonia, carbonic acid, and empyreumatic oil were freely disengaged. Vauquelin however supposed that, with greater care, the hair might be dissolved without such destructive results occurring. This solution makes up the principal part of the hair, but he thinks it is not gluten, although freely precipitated by tannin, because it will not jelly. In both experiments much sulphuretted hydrogen was disengaged. In the course of his inquiries, Vauquelin ascertained that the composition of different coloured hair was also not all the same; in *black* hair, he found an animal substance, of which its largest portion consisted, a white concrete oil, a large quantity of greenish-grey oil, iron, some oxyde of manganese, phosphate of lime, a little sulphate of lime, muriate of soda also in small quantity, pretty much silica and also sulphur—*red* hair has less iron and manganese, and no greenish-grey, but a blood-red oil—*white* hair has still less iron and manganese, and its oil is colourless, but it contains much phosphate of magnesia, which is not found in any other hair.† The observations on this subject have been recently still further carried out by Jahn; he found that the fair hair of children boiled in water scarcely an hour gave out sulphuretted hydrogen gas; this odour was not however apparent so speedily in the hair of older persons, yet was more enduring; but in grey there was not the least trace of it. In children's hair, so soon as boiling commenced, a slight scum rose to the surface, earlier in fair than in dark hair, but in that of old people it never appeared. Beneath the scum a few drops of oil were seen, but never when the scum was absent. By treating this solution of children's hair with tincture of galls, a deposit took place, which did not in older hair. In both solutions soap was discovered, but only in that on the surface of which drops of oil had been seen previous to dropping in tartaric acid, was free oil found. A second boiling of either kind of hair gave no trace of oil or soap. Only after four boilings was something separated without any scum from light hair between fifteen and forty, and then only shown by re-agents; this continued

* See Gualtier, *Recherches sur l'Organisation de la Peau de l'Homme et sur les Causes de la Coloration*, p. 35.

† See *Annales de Chimie*, vol. lviii. p. 41.

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to occur up to the eighth boiling. Dark hair of similar age, fair and dark hair from the heads of old persons, and grey hair, was subjected to five, seven, and even ten boilings, before any gelatinous matter was thrown down. The fluid from the dark hair of persons above forty alone gave, after being freely evaporated and cooled, a sort of brawn which dried into a kind of horny jelly. By these repeated boilings, the hair was very much softened, but it was not dissolved, and merely deprived of its elasticity. By the employment of Papin's digester, Jahn also found that the fair hair of children was completely destroyed in the course of an hour, but from their dark hair he obtained a brownish resinous like substance, which seemed to be inspissated oil. Between fifteen and forty, fair and dark hair, after an hour and a half's similar treatment, left the same oil, but the former left a reddish, and the latter a black resinous like matter. In still older hair, the quantity of this resinous matter diminished, but became more viscid; in grey hair it was least of all, and not viscid, but hard. Of the resinous matter little was dissolved by alcohol or æther, but the largest quantity from that which was hard and obtained from grey hair. Muriatic and sulphuric acid very easily dissolved this matter, and the solution appeared like tannin. Pure potash and carbonate of potash effected the solution of the hair, and formed with it a soapy mixture soluble in water and in spirits of wine. From these and other observations, Jahn draws the following results: 1st. That the soap which is found depends on a solution of the sebaceous matter; 2nd. That the pure mucus found in all hair principally results merely from the solution of its covering; 3rd. That the other membrane of the hair and its fibres approach, according to age, more nearly sometimes to albumen, sometimes to gelatine, and sometimes to mucus, precisely as do the fibres and membranes of muscles; 4th. That the colourless oil abstracted by alcohol is obtained from the colourless fluid found between the membrane and the inner tube of the hair; 5th. That the coloured oil taken up by the alcohol is the coloured oil found in the tube itself, although, when extracted by the alcohol, it is much paler than when in the hair itself; 6th. That at least the greater part of the iron, sulphur, and magnesia found in the hair are connected with the coloured oil; 7th. That the resin evolved by boiling in Papin's digester is formed not merely from the oil of the hair, but in part also from its other more solid parts.*

The hair, as Meckel has well remarked, exhibits very decided periodical changes as to texture and colour, and on certain parts of the body it is not developed till the age of puberty approaches, and of which it forms one of the characters. Till the fifth month of fœtal existence the whole surface of the body is entirely free from hair, but about this time it begins to be covered with a very fine thin hair of a downy texture, which is called the Down-Hair or Milk-Hair of Infants, *lanugo infantium*, and is freely imbued with the cheesy varnish overspreading the fœtus to protect the skin from the amniotic liquor. Eble says—that, according to his own observation, the production of this down is consentaneous with that of the fibrous structure of the hide, and that it first appears on the head, and very soon after on the other parts.† Albinus and Weber say, that the down shoots through the ducts of the sebaceous glands, and through them only, and that not a duct even on the nose and ear is without such sprouting down. At six months Eble found the hairs of the head about three lines long, those in the eyebrows two lines, and the eyelashes a line and a half long; in the former the root could scarcely be distinguished, but in both eyebrows and eyelashes it was; and in all, the cortical and medullary parts of the hair-shaft, and even in the transverse partitions of the latter: this observation contradicts Bichat's assertion, that the down consists only of cortical substance. The down is usually about the same length every where, but rather exceeds on the head. At first it is pale, but towards the termination of gestation it has acquired a darker colour, and not unfrequently the child when first born is well covered with it; but in the course of the first month of its independent existence the down is shed, and in its place true hair begins to make its appearance. Meckel states that the downy hair of the head is not shed, but continues growing and much more quickly than the hair of other parts; this however is not always the case. The hair during childhood is generally more disposed to be silky; and as to colour, it is commonly many shades lighter than it will ultimately become: thus usually children who are born with white hair, have it afterwards changing to yellow, those which have it yellow change to light brown, whilst the latter most commonly becomes dark-brown, and red hair frequently black. The beautiful efflorescence of the hairs on the glowing face of a very young and specially light haired child just waked from sleep, has been as elegantly as truly compared by Lorry to the bloom on recently plucked fruits, or, in his own words, "*quæ vaporem tenuem rori fructus recentes ab arbore decoranti æmulum.*"* On the approach to puberty, the reproductive organs and consentaneously with them the armpits, in both sexes, begin to be clad generally with curling hair, and in the male the beard also commences sprouting, and the limbs show signs of incipient hairiness, and the latter is not unfrequently observed in girls. Just previous to this the surface of the skin is seen studded with numerous little knobs, giving the appearance of goose-skin; these are the germs of the new hairs, and so soon as the latter burst through, the little knobs flatten and gradually disappear. Not unfrequently in young women a few hairs sprout from the corners of the mouth, and after a short period cease to grow; but more rarely the whole upper lip is covered with a downy mustache. In women who are past child-bearing, it often happens that a veritable mustache makes its appearance on the upper lip, one of nature's freaks, which is more fully carried out in the not unfrequent change which occurs in the plumage of an old hen-bird to that of a cock. Two very remarkable instances of these peculiar growths are mentioned: The Bearded Dresden Virgin, whose picture hung in the gallery of the Kings of Poland and Electors of Saxony in 1732, and of whom an account is given by Michaelis. Her beard grew only on each side of the chin, was snow white, and three inches long, but on its middle, and also upon the upper part of the lower jaw, there were *no* hairs; the upper lip however had blackish hair scarcely half an inch long. At first she cut it only once a month, subsequently twice, then once a week, and at last twice,

* See his *Lehrbuch der Chimie*, sec. 931.

† See Eble, *loc. cit.* vol. ii. p. 70.

* See his *De Morbis cutaneis Tractatus*, p. 13.

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Zoology. She endeavoured to conceal it, but having been taken ill, she came into the hospital at Dresden when sixty-four years old, where she soon attracted general notice. She was very dauntless, her voice powerful, and her spirit equally high. She frequently seemed dull and peevish; ate nearly raw bacon and fat, and boiled calf's pluck, with which she always drank wine. Although so gluttonous and insatiable, she slept well, and had her usual monthly periods.* The other instance is mentioned by Eble, a woman who, during the reign of Maria Theresa, served for many years as a hussar, and for her valour was raised to the rank of captain. She had a strong mustache, which she allowed to be shaved. Her sex was at last discovered, and she was allowed a pension of six hundred florins, but was compelled to wear women's clothes.†

Towards the latter end of life, frequently, though not always, the hair changes to grey or falls off, and the person becomes bald, and sometimes both occur at once. Meckel says, that "earlier or later, usually about the thirtieth year of age, the hairs, in consequence of the shrinking of their inner substance, begin to whiten, and somewhat later, after their exterior has fully grown, their connection with the capsule in which they are found is destroyed, and they fall out."‡ Eble considers this, and not incorrectly, as too early, and observes, that he may at least fix the commencement of greyness at about the fortieth year. The loss of colour is generally gradual, but occasionally under violent mental excitement it takes place in an almost incredibly short space of time; instances are mentioned in which a person has been known to become grey almost instantaneously by fright. The writer of this Essay has known one instance of a banker whose hair became grey in the course of three days when under much anxiety during the great panic of 1825; and also another gentleman who, at his marriage, when about forty years old, had a dark head of hair, but on his return from his wedding trip, had become so completely snow white even to his eyebrows, that his friends almost doubted his identity.

Bichat says, that after the grey hair falls out, the sac from whence it sprang diminishes, and at last entirely disappears; that he had examined many bald heads, of which the skin was entirely smooth on the inner side, although all the cellular tissue had been removed; that there is not a trace of the innumerable appendages which are the conduits of the hairs, after such hairs have been removed, and this he contrasts with the case of a person who had become almost entirely bald after putrid fever; "all the little conduits were entire, and at their bottom was even seen the rudiment of a new hair. This then is the difference between the loss of hair in old persons, and that consequent on disease, that, in the former, the whole dies, because the vessels going to the root cease to transmit the fluids, instead of which in the latter, the hair only falls, the sac remains entire."§

Many instances have however occurred, in which not merely the colour of the hair was recovered, but even fresh hair sprouted out in persons far advanced in life: thus, John Weeks, who lived to the age of a hundred and fourteen, had his hair again brown some years before his death; and a Scotchman, who died at a hundred and ten years of age, had re-acquired his blond hair several years prior to his decease.* Susan Edmonds, in her ninety-fifth year, had her hair again become black, but shortly before she died, in her hundred and fifth year, it again became grey.

The functions of the hair of animals have been divided by Eble into general and particular; under the former he includes—1st, those which belong to all hair; and 2dly, those which have a peculiar influence and effect upon the whole economy, or on the entire vital process of animals; under the latter he comprehends all those by which some one particular object of a particular part of the organism is specially fulfilled.

The general uses of the hair include Absorption, Perspiration, and Electric distribution.

As to *Absorption*, the examples given by Eble are by no means satisfactory. He adduces, in support of his opinion, the hygrometric property of hair, by which, according to the moisture or dryness of the atmosphere, the hair is more or less soft, flexible, and swelled; this however is not absorption, but imbibition, and differs not from the softening or hardening which takes place in a piece of inorganized gluten when exposed to an atmosphere moister or drier than itself. Neither is the roughness produced in hair by washing it with infusions of bark, alum, &c. any proof of absorption; it merely effects the same chemical action upon it as it does upon a hide, and its increased softness and flexibility, on the application of oil or grease, is exactly what occurs in tawing leather. The greenish colour frequent in the hair of coppersmiths, which he brings forward as another instance, is equally inapplicable, and it seems to be merely a kind of dyeing, although Laugier, who some years since obtained copper from the hair of such persons, is disposed to think that the green colour of the oil in the hair depends on the presence of that metal.

*Perspiration.*—The opinion that the noxious humours of the head were discharged by the hairs, as by so many excretory ducts, is as old as the time of Galen. Malpighi thinks that "the hairs probably conduce to the excretion of sweat;" but it is evident that the sebaceous matter is what he really means, for he says immediately, "so that an unctuous matter should gradually flow and be evolved from the body through the hairs; for I have elsewhere observed, that there are glandules with four chambers opening into a common duct on the human face, from whence sprouts out the hair slender and short, through which an unctuous humour gradually ascends, and distilling by its affusion on the adjacent skin, protects it from the injury and action of the eroding salts of the atmosphere."† The unctuous matter is known to be poured from the sebaceous ducts, which Gurlt has shown to empty themselves always into the capsules of the hairs, but the perspiratory ducts always terminate distinctly: as, however, this was not known in Malpighi's time, it is not very wonderful that he should have held such opinion. Haller, in what he calls the "perspiration of fat," says, "not a few writers are persuaded that the very hairs exhale, and even show the apertures by which the medulla exudes. Doubtless, although we know not the way, it is necessary that the medulla which is continually produced should be got rid of and exude as the growth of the hair requires."‡ This exactly corresponds with Malpighi's statement, and

* See *Michaelis in Acta Academiæ Naturæ Curiosorum*, vol. iii. Observ. 127.
† See Eble, *loc. cit.* vol. ii. p. 81.
‡ See Meckel, *loc. cit.* vol. i. p. 600.
§ See Bichat, *loc. cit.* vol. iv. p. 824.

* See Sir John Sinclair *On Longevity*.
† See Malpighi, *loc. cit.*
‡ See Haller, vol. v. p. 44.

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is explicable in the same way. Fourcroy thinks the hair serves to the excretion of the excess of phosphoric acid, with which opinion Vauquelin agrees, they therefore consider it as participatory in the excretory function of the urinary organs.

Eble is disposed to think with Oken, that the hairs may be "respiratory organs (similar to the tracheæ of insects); that they are simple gills which are dried by the air, and in the respiratory process perform only the electric or oxydating part."* And he grounds this opinion upon the fact, that in the lower animals, where no trace of gills or lungs can be found, the whole surface of the body is covered with hair or hairlike elongations, which he thinks should be considered, more than probably, simple cutaneous gills, by means of which oxygen is abstracted from the air or water, inasmuch as the hairs of insects are at first true gills, which subsequently become dried, and are then in the same state in which the hairs of the higher classes are always found. And he further observes, that the two classes of animals in which the hair-system is most fully developed, viz., insects and birds, are distinguished above all others by their predominant respiration. This opinion may be summed up in his own question, "What prevents our holding, that by the secretion of the pigment in the hair-roots, the blood gets rid of its carbonaceous parts, and is also impregnated over the whole surface of the body with the oxygen of the atmosphere?"

*Electric distribution.*—There is no doubt that, by friction, hair can become negatively electric, and that wherever it finds it takes up and concentrates the electric fluid, so that it becomes both a true condenser and a bad conductor of electricity. There are few persons who are not aware that friction of the hairs of a living cat will produce electric sparks; and Jahn himself observed two men, one with red and the other with black hair, which in clear wintry weather gave out sparks by friction; these were more frequent from the red hair, but there was most crackling in the black. He also mentions that a friend of his knew a man who was surrounded with a luminous appearance in a thundery atmosphere, and that upon the approach of a storm he was always much excited, but afterwards so much exhausted that it was difficult to prevent him falling asleep.

With regard to the modifications which the hair exhibits in brutes, it may be divided into straight hair and wool; in a large proportion of beasts, both kinds are found, though one is usually in larger proportion than the other.

Straight hair varies considerably in its length and texture, as may be seen if the hair of the horse be compared with that of the rabbit, it being shorter and coarser in the former, longer and softer in the latter. Generally speaking, the longer kind of hair is called *fur*. But even in the same animal, the hair differs: thus their general hairy covering is shorter and more delicate than the manes of beasts, and the long hair of the tail, but especially the stiff bristles implanted in larger or smaller quantities about the muzzle, and often in tufts near the eyes. These bristles are commonly called *Whiskers*, a term which is quite inapplicable; it would be much better to call them hairs of touch or of smell, for it is probable that they assist in both those functions, and in the latter especially, as, if an animal be watched whilst carefully smelling any object with which it is desirous to become better acquainted, these bristles may be seen in free motion; not improbably also they may entangle the odours contained in the air, and thus bring the scent of their food more immediately to their nostrils. Into these *whiskers*, nerves can without much difficulty be traced from that branch of the trigeminal nerve which is distributed to the muzzle.

These hairs, generally speaking, have the same structure as that already described. The bristly tuft at the extremity of the elephant's tail, the bristly beard of the seal, the tail of the horse, and the bristly hairs with which the bodies of swine are covered, Heusinger considers as peculiar; he calls them *horny bristles*, and describes them as "appearing on a transverse or longitudinal section, perfectly smooth, like very close horn, and specially having in their centre a canal. They are smooth, glossy, tough, and flexible, like a true horn."* He gives a particular account of the beard of the seal, and says that their base is implanted in a sheath, but without any round or oval enlargement, such as exists in the greater number of hairs in general; that the larger ones are compressed and flat, with irregular edges, as if they had grown spirally, as the smaller ones do without presenting the flattened form; that with the naked eye at the bottom of the base a small brownish-red round spot can be observed, whence a streak ascends about an inch up the stem, then thins and losing its colour, gradually disappears towards the tip; thus when a transverse section is made there is at the base evidently a canal, which contains a brownish-red pigment, or probably coagulated blood; but in the shaft the cavity only is found. The bottom of the sheath on which the base of the bristle rests, consists of a tough hornlike, elastic, vesselless substance of an oval form; the upper opening of the sheath is very narrow, but has no connection with the bristle, and its interior is smooth as a serous surface. In swine the bristles are quite flat, without any spiral appearance, and their tip splits into three or four points, in the midst of which the canal extending through their whole length, but divided into little chambers by transverse partitions, opens. From this description it is evident that such bristles have a close resemblance in their growth to that of horns, such as that of the rhinoceros, or to the longitudinal fibres of the horse's hoof, and the little process at the bottom of the sheath is probably only a papilla less developed.

Wool is very fine hair, but remarkable for its disposition to curve. Bloch and Weber say that the finest wool, of an inch in length, will make from thirty-one to thirty-six curves, the number diminishing as the wool gets coarser, till at last not more than ten turns can be counted. It has also great disposition to mass together. Heusinger thinks it probable that it grows spirally, and says that in many kinds of wool which he has examined, he has found the shaft of the hair not of equal thickness throughout, but thinner at regular interspaces, where the hair curved upon itself, and in some of these parts even flattened. He could not ascertain any material difference in it from other hair, except that no distinction between the vertical and medullary part could be ascertained. He also observed that it is impossible

* See Eble, *Op. cit.* vol. ii. p. 151.

* See Heusinger, *loc. cit.* vol. i. p. 176, *et infra.*

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to pull out the wool from an animal without pulling out also some of the long hairs with which it is interspersed, and around which it disposes itself in locks, not because, as he at first thought, the wool sprung also from the root of the long hair, but because the roots of both are intimately connected. The texture of wool, like that of other hair, varies considerably; sometimes it is coarse and rough, sometimes it is quite silky. Bloch says that the hair of a Cashmere goat has a diameter of [illegible] to [illegible] of a Paris inch; and according to Thaer's account, he has found, though very rarely, some of the finest wool of greater delicacy, viz. [illegible] of an English inch, whilst his *choice* wool measures from [illegible] to [illegible]; that of the first quality from [illegible] to [illegible], and of the second, above [illegible] of an English inch in diameter.

Wool is found in many other beasts besides sheep, but is not visible, unless the fur, or long straight hair, be turned back, when the short wool is seen closely investing the body, and, throwing the fur farther from the hide, gives the animal an apparent size which it does not possess, of which the otter and the water rat exhibit very good examples.

In birds, hairs or bristles about the nostrils are by no means infrequent, especially in many of those which feed on insects, as the owls, shrikes, goatsuckers, &c., and this would further support the notion of their being auxiliary organs of scent, rather than for the purpose of preventing the escape of the captured insect, as supposed by Swainson.

The coat, as the hairy covering of beasts is commonly called, changes twice a year, or is *shed*, as the common expression is, in spring and in autumn; at the second change it is more thick and full, to provide against the diminution of temperature. It also, in many instances, undergoes an accompanying change of colour, of which our common stoat or ermine is a very good example, its reddish-brown fur becoming white, with the exception of the tail, which still retains its dark colour; this change occurs regularly in high northern latitudes, and occasionally, though rarely, in this country, so that the mere change of season converts this inveterate destroyer of game itself into a prey to the hunter, for the sake of its ermine spoils. The whiskers, mane, and tail, however, in such animals as are furnished with them, are not shed, but, like the human hair, are in a constant and slow state of growth.

In brutes, the hair performs a much more important function than in the human subject, as on them it not only serves to their adornment, a far from trivial office, if we observe the vast variety and beauty arising from texture, colour, and disposition of the hair of these animals, but it is literally their clothing; and its thickness and quantity is almost invariably in proportion to the thickness of the skin: thus if the hair be thick, long, and shaggy, generally speaking the tegument is, comparatively with the size of the animal, thin, and the contrary. It corresponds also to the temperature in which the animal lives: thus it is thick and full, and often based in close wool in those which exist in very cold climates, whilst in the inhabitants of high temperatures it is thin and almost silky, and commonly very short. In such animals as have it largely developed in shape of spines, it becomes a powerful organ of defence to an otherwise most defenceless being. The so called whiskers of animals must also be considered organs of sense; this has already been mentioned, and in support of their use as organs of touch, Vrolich's experiment may be here mentioned, in which a rabbit, whose whiskers had been cut off and its eyes bandaged, was unable to find its way out of a narrow passage made up of books, without pushing. In addition to these uses which the hair serves in the higher classes of animals, it is also in many of the lower animals a motive organ, of which hereafter instances will be adduced.

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### *h.* Spines, *Spinæ*.

The spines which are found in the porcupine, hedgehog, and echidna, are scarcely to be considered other than large, stiff, unbending hairs. The spines of the hedgehog have been examined by Heusinger, and according to his account the spine-sheath is very delicate, white, much resembling the tegument, and, though closely investing the spine-root, only connected with it at bottom. The root of the spine is somewhat globular, and in its base is a conical hollow, which receives the former two organs, supplied with vessels from beneath; as it rises in the cavity it tapers to the neck of the spine, where it terminates. The shaft springs up slenderly above the root, but soon acquires its full size, and continues nearly cylindrical to the tip, where it again tapers and terminates in a point; externally it is minutely furrowed. A vertical section shows it to consist of three different substances; in the centre, a mass consisting of large cells piled on each other, composed of a tough, white membrane, similar to dried, serous membrane, completely vesselless, and filled with air; these are surrounded with rows of still smaller cells of similar structure, and also filled with air, which extend from the root nearly to the tip, and this in turn is enveloped in a very tough, homogeneous, horny substance, which forms the walls, and alone points the spine. The whole shaft is above the external surface of the body, the narrow neck contained within the thickness of the tegument, and the root with its sheath implanted in a bed of fat, in the cellular tissue beneath the hide, where it is connected with the muscles moving the skin, by which the spines are erected. As to structure, the spines of the porcupine do not differ from those of the hedgehog, but Gualtier describes them as being arranged in sets, varying in numbers of five, seven, nine, or eleven upon plates of fibrous membrane, probably for the purpose of enabling the porcupine to move them in different directions so as to produce the startling rattle, which this harmless animal is capable of making, as its principal mode of defence when attacked.

### *i.* Feathers, *Pennæ*.

As by far the greater number of the class of beasts are covered with hair or fur, so that it becomes one of their proper characters, in like manner also their feathery covering or plumage is a distinguishing attribute of birds, and exhibits the highest degree of development to which the modified dermal tissue can attain.

Feathers are of various kinds, some approximating in form and structure nearly to the spiny hairs of the porcupine and hedgehog, and others to the bristly hairs about the muzzles of beasts.

Every perfect feather consists of three principal parts, the *barrel*, the *shaft*, and the *web*.

1. The Barrel, *scapus*, is the part which is implanted and concealed in the skin. It is a horny tube, varying

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in length, more or less cylindrical and more or less transparent. Its lower extremity is somewhat conical, with its tip deficient, and thus leaving a space which would form a hole, were it not overspread by a delicate, smooth membrane, which, being upraised a little towards the interior of the tube, forms a depression commonly called the *lower navel*, but by some German writers, the *dimple*, and in which is a small aperture for the passage of vessels and nerves to the cavity of the barrel. At the upper end the horny barrel disappears, at least it begins to lose its cavity, and then commences the stem of the feather. This subsidence of the barrel into the stem does not take place equally; it begins to fill up and to become opaque in front, at a second little depression, called the *upper navel*, which is on a level with the lowest part of the web of the feather, and is rendered visible by a little tuft of hair-like processes implanted in it, and by its forming the extremity of a groove which proceeds to the very tip of the feather. On the back of the feather, however, the transparency of the horn is continued some way up on the stem. The disposition of the horny fibres constituting the barrel are usually described as circular or oblique externally, but longitudinal within. If the barrel be cut open lengthways, it is found to be filled with a soft, dried, delicate and semitransparent horny cylinder, irregularly shrivelled, and somewhat like a string of ill-assorted beads, which is attached below to the lower navel, and ascending to terminate in the upper navel, more or less completely fills up the barrel, and is called the *pith* of the feather.* Eble considers the contractions of this cylinder to divide it into so many cells, the smaller of which are at the lower, whence they gradually increase in length to the upper navel, but all communicate by a central canal. The pith, having reached the upper navel, divides into two branches, the anterior of which passes through that passage, filling it up, and appearing as a brownish, hair-like tuft on the surface, whilst the posterior is continued upwards, and is lost in the pith of the shaft.

2. The Shaft or Stem, *rachis*, though usually described as distinct, might not improperly be considered as a continuation of the barrel; it is considerably longer than the barrel, and of equal size and form with it at its commencement, but gradually assumes a square shape, and tapers to the extremity of the feather, the tip of which it forms; it also generally curves a little forwards. It is readily distinguished from the barrel by its opacity, and it commences from that part by two or three narrow streaks, which take their origin below the upper navel, and, spreading as they ascend, at last occupy the whole circumference above that aperture. The back of the shaft is smooth and slightly rounded, but its front is flat and divided into two columns by the *mesial groove*, which, beginning sharply from the upper navel, soon widens and continues of proportionate width and depth to the very tip. The sides of the shaft are flat, their front edge is free and somewhat rounded, but immediately in front of their hind edge the web of the feather is fixed. The horny, external part of the shaft is thicker on its back than on its front, and on the thickness of the hind wall depends the toughness of the shaft, as its front and sides are very thin; hence also the back of the shaft is considerably more glossy than the other parts. The interior of the shaft is filled up with a white cork-like substance, *substantia suberosa*, as the German writers very aptly call it, which even in very dark coloured feathers shows through the thin, front, horny covering of the shaft. It begins to appear on the front of the shaft, with its incipient opaque streaks, and gradually increases in thickness from before to behind, till it fills the whole of the shaft to its very tip, but seems to be divided into two columns by the groove already mentioned. In stiff feathers, this matter is more dense, but in those which are flexible its texture is looser; and Meckel says that it is more prevalent, and diminishes, or even almost entirely fills up, the cavity of the shaft in heavy flying birds, whilst in those which soar high, the cavity is not filled by it till much nearer the tip.

3. The Web of the feather, *vexillum*, consists of the shaft and of the two *vanes*, the inner and the outer, *pogonium internum et externum*, each of which is made up of a succession of flattish, flexible fibres, rays, or barbs, *telæ*, *radii*, regularly disposed on each side of the shaft, like the leaves of a book. Each barb has a little shaft or stem by which it is connected to the principal shaft, and thence stretches out, increasing for a short distance in breadth and then gradually narrowing to the tip, which is pointed; it is flattened from above downwards, is usually hollowed on its upper surface to receive the convex under surface of the superjacent barb, and its edges are fringed with a series of little rays, called barbules, which are sometimes simple and at other times branched, so that each barb has, under a microscope, the appearance of a feather in miniature. Upon the closeness with which the barbs lie in each other depends the close or loose texture of the vane, as may be seen on comparing the close web of the wing-quill feathers of the goose, commonly used in writing, with the loose webs in the tail-quill feathers of the peacock. Sometimes, indeed, the barbs are so consolidated together, as in the webs of the wing-feathers of the penguin, that the feather resembles a scale. In all feathers the stem of the barb is of greater length in proportion as it is near the origin of the vanes, which commence on each side of the shaft, a little above the upper navel, first short and then gradually lengthening till they attain their greatest length, which is acquired at various distances from the tip of the feather, according as it is round, square, or pointed; and from the longest barb the length gradually diminishes to the tip of the feather, in proportion to the circumstances just mentioned. At the beginning of the vane, even in webs of close texture, the barbs do not lie in each other, but are loose and pendent in consequence of the length of the barb-stem, hence they are called floating barbs; of these, in the quill feathers of the wings and tail, there are but few; in the feathers covering the body, they are, on the contrary, very numerous, often form a fourth and sometimes even one half of the total length of the vane, so that the lower part of the vane is more or less open, whilst its upper part is close; and it may be observed that, in all those feathers specially concerned in flight, the barbs are more closely received into each other, and throughout a larger portion of the vane, for the purpose of preventing the passage of the air through them, which would diminish the impulse of the wing when struck down in flying; the fringed edges of the barbs are also doubtless to promote the same object.

The barbules of the barbs are remarkable for the swellings or little knots, generally opaque, by which they are overspread, varying in the closeness of their

* See Eble, *loc. cit.* vol. i. p. 132.



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approximation, in their form, &c., not only in different birds, but in different parts of the same bird. In many birds they are cylindrical and heart-shaped, triangular, and pyramidal in the goose; discoid in the pigeon, cleft in the middle in the peacock and jay; cleft and pointed in the bittern and peacock, according to Heusinger; whilst, on the other hand, in the passerine birds, Meckel says they are flat, pointed towards the stem and broader towards their tip; quadrangular, discoid, strongly projecting, but gradually becoming smaller and rounder in the pigeons.

Besides the distinction which these little swellings on the barbules makes between the true plumage and the down of birds, they are of much greater importance, as Heusinger, Audebert, and Nitzsch hold that the different colour of feathers depends principally upon the different condition, form, position, number, and size of these little swellings on the barbules. The horny substance, however, of the barrel and of the web in some degree modify the colour of the feather, whilst its brilliancy depends partly upon the relative position of the coloured parts, and partially upon the colouring matter itself. Heusinger divides the colours of feathers into the dingy, the metallo-glossy, and iridescent; those of the first kind have nearly the same form; but the rays of the second are generally very hard and, according to Audebert, specifically heavier than the former.

Besides the feathers proper, which have just been described, there are also found beneath them, and closely covering the body, some short, delicate, and soft feathers, which are commonly called *down*. They project from a membranous sheath, (which will be presently noticed,) usually a few lines in length, and from its upper opening protrude the peculiar parts of the down. On removing the sheath, a very short stem is observed, and springing from above the external opening of the pith, are seen an irregular number of long, very soft, and delicate downy fibres; their attachment, however, is so loose that they generally separate with the sheath. The barrel then springs up as a proportionally very long stem, round, hair-like, and smooth to its tip, where it divides into a number of fibrils, resembling itself in form and structure, except that they are still more slender. Under a strong glass both stem and fibrils appear filled with loose cellular tissue, similar to that of hair, but much thicker and irregular.* It will thus be seen that the down is distinguished from true feathers, by the absence of any thing resembling barbs or barbules, and by their nearer approximation to hair. The fibrils usually drop off very soon, and leave the stem alone remaining. Some birds, as those of the rapacious order, are covered with this down when first hatched, but in others it does not appear till some days after hatching. Sometimes the down is entirely thrown off when the plumage has become fully developed, but at other times, as in water birds, it remains constantly, or is reproduced with the plumage; and it bears the same relation to feathers as the woolly hair which closely invests the body of beasts does to their fur. The colour of the down is mostly brown, yellow, and streaked with black, in land birds, but in water birds is yellow and greenish.

The feathers are connected with the body of the animal by their barrel being received into a tough, membranous bag, which is called the *horny sheath*; it covers young feathers a little way above the skin, but when they are perfectly formed, it ceases at the skin, and uniting with it forms the cuticular ring, and at this part only does the skin touch the barrel. The horny sheath terminates below at the pit, and becomes connected with the epithelium. The barrel and its sheath are fixed in a canal, as the hide rises along the former, and the canal is of proportionate length with the barrel. Externally it is formed of skin, which, terminating at the upper opening, is connected with the horny sheath and the epithelium of the canal; beneath the skin is the somewhat thickened and tough hide. Within, the hide is lined with a very smooth and tough epithelium, which closely surrounds the barrel and its sheath, but is never connected except at the upper opening. Some hold the epithelium to be merely an engulphing of the skin, but this Heusinger denies. The little pit is covered neither by the horny sheath, by the epithelium, nor by the hide, but is connected with the subcutaneous tissue, with the aponeurotic and muscular fibres, which here fix, and serve both to steady and move the feathers.

The *formation and growth of feathers* has attracted much attention, and is a subject of much interest, as by their more simple form as down they are connected with hair, with which, as already mentioned, the down has, in reference to its interior structure, close resemblance, whilst its branching disposition approximates it to hair. The following are the opinions of the writers most worthy of attention on this point.

The production of a feather, as described by Malpighi,* is as follows. Birds, recently hatched, are covered with yellowish hairs, which burst from a follicle, as from a root, in little bundles of more than twelve, and spread on the surface of the skin. These, if followed by tearing away their sheath, are seen to spring from the top of a very small, delicate, transparent follicle, containing the rudiment of the feather, which, as it grows, presents the appearance of a black sheath beneath the skin. The sheath or membranous tube is inserted in the hide, on a papilla perforated in its centre by the umbilical vessel of the former, which, if torn away, is followed by bleeding. Within the sheath is contained a softish, mucous follicle, of an ashy colour, with bloody spots; but although it seems to consist of fibres longitudinally arranged, there is really no organic structure but the umbilical vessel which runs through it lengthwise. From the sides of the follicle, about its base, little black plumules arise, and from its tip some white ones, from which hairs stretch out, and the tip of the sheath opening as the growth proceeds, the extremities of these plumules with their conjoined hairs burst forth, and the sheath being farther opened, the follicle appears, forming the stem, dried at its tip, and divided into empty membranous chambers, whilst its remaining or lower part is softish, and gives origin laterally to the plumules with the hairs, which, when the sheath is torn off, are withdrawn with it, and the whole extent of the stem, from the tip to the bottom of the follicle, is seen; the follicle, as an uterine placenta providing the growing material of the feather, presenting first the upper, subsequently the lower part of the stem, and finally the barrel of the feather. The follicle is a cylindrical tube formed of delicate membrane, inclosing a series of utricules of different size, proportionate to the quantity of fluid contained, which is gradually absorbed in the growth of the feather; thus where the fluid is actively

* See Heusinger, *loc. cit.* vol. i. p. 218

* See his *Opera Posthuma*, p. 96.

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propelled, the chambers are conical, as may be observed when vegetation first commences about the stem, the apex of which is first gradually lengthened; to this succeeds the production of the barrel, when the chambers again elongate towards its apex, but as they descend, the resistance of the cartilaginous tube compels a change of form, and the conical shape being lost, the chambers assume the appearance of numerous valves piled on each other. When the generation of the feather is perfected, the barrel or elongated tubular part of the feather becomes solid. The barrel is a cartilaginous substance, by which probably the whole stem is covered, and being folded externally forms the plumules, and finally hollowing itself into a tube forms the barrel. At the part where the stem ends in the hide, the shrivelled follicle bursts forth, but the rest is contained within the barrel, the external membrane of which, so closely connected at the middle that it can scarcely be separated, is obtained from the sheath, but the upper part subsides into scales. If the barrel be opened prior to its solidification, the contained follicle is found loaded with fluid, and externally its thick investment is overspread with blood-vessels. When the growth is completed and the feather becomes solid, plumules are produced from the cartilaginous substance, and the remnant of the dried and protruding follicle is apparent, as also the solid pointed tip of the barrel with its aperture. The shrivelled follicle contained in the barrel contracts into a variable number of chambers, exceeding twenty, which are sharper at the upper part, where the still recognizable umbilical vessel may be traced to the protruding part of the follicle, more obtuse in the middle, and more numerous at the bottom. The interior of the stem is filled with numerous, very small white vesicles, resembling elder pith, and mostly of an oval shape, extending from the insertion of the follicle to the very tip of the feather.

Cuvier* adds but little to Malpighi's statement. He says if the sheath be opened just as it penetrates the skin, it is found to consist of numerous cylindrical layers of horny and transparent matter, inclosing a cylinder of gelatinous substance, in which blood-vessels run; that its top is conical and much harder than the other part, and that it is enveloped with a layer of black matter, which is the first rudiment of the barbs of the feather, which, when the cylinder bursts the sheath and is exposed to the air, splits as it dries, and forms the first barbs, and that the stem of the feather elongates and hardens at the same time. More of the cylinder then protrudes, and an additional quantity of barbs and stem are thus produced, till the whole of the vanes and shaft are perfected. After which the barrel or tubular part solidifies and becomes continuous with the shaft, of which it had previously contained the germ.

The formation of a feather, according to Dutrochet,† takes place in the following manner. At the bottom of a canal of greater or less depth than the hide, similar to that from which a hair springs, is a little bulb covered with skin or epidermis, and which he thinks is merely a dermal papilla. This little bulb increases gradually to the size of the feather it has to produce, and its external skinny covering, thickened by additional internal layers, at last forms a whitish tube completely closed except at the lower part, where an aperture, or sort of navel, exists for the passage of vessels to the bulb contained within it. If this epidermal tube be opened early, the rudiments of the terminal barbs of the feather are seen, soft, and resembling a layer of colouring matter, commencing from the circumference of the navel and winding obliquely round the bulb; but there is not any appearance of stem. When the barbs are perfected, longitudinal horny fibres spring from their lower part, which form the commencement of the hinder and fore part of the stem; new barbs form below and send off more horny fibres, a process continued till the whole stem is perfected. During this development the point of the feather bursts through the upper end of the epidermal sheath, and that part of the feather which is perfected protrudes, and the previously folded barbs, drying, begin to expand. When the feather has grown to a certain size, he states that the production of the anterior horny fibres of the stem can be seen taking place, not like the posterior fibres at the circumference of the navel, but more closely to the tip of the bulb, which in the growth of the feather rises above the navel and supplies the juices for the production of these fibres, which, joining together in the middle, form the raphe or mesial depression, extending along the stem from end to end. At first, these anterior as well as posterior fibres form each a plate which are in contact, but subsequently are separated by the spongy matter deposited between them, which gradually increases in quantity till the stem acquires a squarish form. The growth both of the horny fibres (which especially on the front are connected with the bulb like a nail to its root) and of the spongy matter, which Dutrochet considers merely a modification of horn, is effected not externally but from within, an abundant quantity of lymphatic (albuminous) fluid being produced by the bulb for that purpose. The bulb itself, very vascular, of a conical form, terminating in a point above, has its expanded base connected to the hide by a very slender pedicle, which penetrates the navel of the epidermal sheath and receives the vessels and nerves for its supply. It is covered with a sort of epiderm which is thicker as it approaches the tip of the feather, so that the feather is found contained between two epidermal membranes, the epidermal tube, the continuation of the general epidermis of the animal, and the epidermal membrane which closely invests the bulb. When the epidermal tube is burst by the rising end of the bulb, the epidermal membrane comes in direct contact with the air, which dries and forms it into a kind of cap; the membrane is again reproduced at this point, as it rises is again dried, and acquires the cap-like form, which is sometimes only received within the former, and at other times connected with it; this process is repeated so often as the point of the moist epidermal membrane is exposed, and thus a series of caps or cones are produced, at first above the point of the bulb in a case formed by the folded barbs, but subsequently they are found within the barrel of the quill, and form the so-called pith of the feather. Having thus accounted for the growth of the barbs and stems, he next describes that of the barrel in the following manner. The circumference of the navel, having become gradually beset with barbs, extending forwards on either side of the first formed terminal ones, is now surrounded by the horny fibres produced from the hind part of their lower ends, which at first forming the back of the stem gradually expand it in a circular direction, till it at last forms a cy-

* See *Leçons d'Anatomie Comparée*, vol. iii. p. 604.

† See his *Observations sur la Structure et la Régénération des Plumes, &c.*, in *Journal de Physique*, vol. lxxxviii. p. 333.



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linder, the barrel of the quill, which then elongates itself below till the barrel has attained its full length. The period at which the cylinder begins to be formed is when the anterior fibres of the stem and the spongy matter cease to grow, in consequence of the bulb being gradually retracted from them by the posterior horny fibres detaching its connection with the anterior fibres of the stem; the bulb then begins to enter the barrel, and the spongy matter pressing the front of the stem forwards, the aperture by which this entrance is effected closes, and the function of the bulb being now completed, it gradually shrinks in the hollow of the barrel and disappears, leaving as its only trace the succession of epidermal caps, which together with it had been retracted into the barrel.

Fred. Cuvier* does not agree with Dutrochet's opinion of the formative organ of the feather being a dermal papilla; he says, "the whole capsule springs from a papilla of the hide, but is not its development; they have not the least relation as regards structure, and neither are connected but at very circumscribed points; thus, when the dermal sheath is opened at the point containing the lower part of the new capsule, and is followed by the papilla, the latter is seen forming a small cone in comparison with that of the capsule and hardly communicating with it but at its tip." The original form of the capsule is that of a cylinder terminating in a cone, and very soon after the capsule has penetrated the skin, the cone drops off, so as to set free the extremity of the feather. The lower end of the cylinder is closed with a soft fibrous membrane, in which is an aperture for the passage of the nutrient vessels of the interior of the organ, and which represents the navel of the feather, as it performs the same functions, although not found at the same part, the tube of the feather being far from being formed in a capsule with which the development commences. Its whole exterior consists of a membranous covering called the sheath, which gradually thins from above to the entrance of the vessels. When the sheath is opened, two membranes are found, the opposing surfaces of which being striated, F. Cuvier calls the external and internal *striated membranes*; the appearance, however, depends merely on their connection by some little *transverse* (or rather oblique) *partitions*, dividing the cavity between the two into numerous little *chambers*, wherein is deposited the soft matter of the incipient barbs which have the appearance of being folded from below upwards. The partitions are considered to be processes of the outer membranes, and merely connected with the inner, which is the proper membrane of the bulb. The bulb is the central and most important part of the capsule; it alone is in connection with the general organization, and as it alone incloses the vessels and nerves of the feather-organ, it appears to give direct origin to all the other parts of the organ, as well as to the feather itself. The barbs and stem of the feather spring from the upper part of the bulb, and as this elongates, more and more of the feather is produced, so that there is an almost simultaneous development of both, the bulb however being first produced; but so soon as its most fully developed part has performed its office by secreting the barbs and stem, it becomes obliterated, dries and disappears. In proportion to the activity of the bulb, which seems to reside in the base and to be restricted to a certain part of its length, it exhibits, besides the vessels ramifying on its surfaces, some longitudinal, white, soft, elastic fibres, similar to the threads of a spider's web. When the action diminishes, this part changes its nature, membranes in form of lengthened cones are developed upon it, received into each other, and filled up with pulpy matter, which gradually disappearing, these white cones dry and become transparent; they appear at first to communicate by means of a tube which subsequently becomes obliterated. When the formation of the barbs and stem is completed the sheath no longer continues to be projected beyond the skin and thrown off in scaly rings or shreds, but its inner layers become the outer layers of the barrel and are identified with those secreted by the bulb which it incloses. F. Cuvier says that the bulb is a double organ; he however only speaks of it as consisting of an *upper* and an *under* part, the latter made up of a middle striated portion and a pair of lateral pieces smooth and fringed, which he calls *wings*.

According to Albert Meckel,* the vessels at the bottom of the tube-like pit in the tegument in which the feather is to be formed, enlarge and pour out a serous fluid beneath the skin or epidermis: the peripheric part of this fluid coagulates into a membrane, the *sheath*, which appears like a pustule full of moisture and has at its bottom an aperture through which penetrate elongations of the dermal vessels. As it grows, it lengthens toward the surface and acquires an oval shape; the superficial extremity becomes pointed, but the base still remains broad and the sheath assumes the form of a papilla. The vessels which enter, form with this gelatinous papilla, on the surface of which they spread like a net, the *germ* of the feather, the surface of which is covered with albumen to serve as the formative material of the feather. Between the germ and sheath, close to the vascular hole, is a layer of semitransparent globules, which form themselves into rows, and two such connected by similar matter form a fibre of the vane; on either side of each vane is attached a single short row of globules which form the twigs of the vane or fibrils. The fibres are all loose at their tips, but attached towards the base. At the inner opening of the vascular hole the globular mass condenses into an oval streak, on the lateral edges of which the fibres of the vane are attached: these soon expand into a plate, which consists of longitudinal horn-like fibres, tapering towards the tip of the sheath, but towards the vascular aperture terminating in a ring; this is the barrel, and the plate its vane-stem, but the ring the rudiment of its tubular part. On the opposite side, the shaft forms a loose web, growing in two bands from the lateral edges of the barrel-plate, which thicken, coalesce in the mesial line, and together with the barrel-plate form a close cavity in which the extremity of the jelly-like germ is contained. After the vane is developed, the ring of the barrel grows up to a tube, which at its root has but a single opening for the entrance of vessels. The two stripes of the shaft grow together into a single piece at the ring or commencement of the barrel, leaving however an aperture, the air-hole for the admission of air, which expands through the tissue of the shaft and the barrel. The vane is first developed from its tip. The germ then dies, together with its vessels, from its tip to the root, and becomes a slough; piece after piece dries and

* See his *Observations sur la Structure et le Développement des Plumes*, in *Mémoires du Muséum*, vol. xiii p. 327.

* See Reil, *Archiv für die Physiologie*, vol. xiii. p. 37.

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shrivels to a sort of funnel, so that it, now become the *pith*, appears like a chain of funnels received within each other. The sheath at first grows of similar shape with its contents, and protruding out of the pit in the tegument attains the extent of its upward growth, bursts at the tip and allows the protrusion of the vane, which, previously folded up from its dorsal to its ventral surface, now expands, but the sheath remains on the barrel as an adherent membranous envelope, which in the so-called extrication of the feather falls off in scales.

Notwithstanding the opinions just detailed of so high authorities as Dutrochet and F. Cuvier, it does not appear difficult to explain the growth of feathers in a much more simple and satisfactory manner, and which will be more readily understood by comparing it with the analogous growths of hair and horn, and with the former more especially. The comparison also as regards hair is still farther strengthened by the correspondent cause of its periodical shedding in many beasts, and the moulting of the feathers of birds. No direct observation on the former point has been made; but in reference to human hair, Bichat states that when a grey hair has fallen out, the sac whence it sprang diminishes and finally disappears; and it may be fairly presumed that such is the cause of the shedding of the coat in beasts, as it will be presently perceived to be the cause of the moult of birds.

Agreeing with F. Cuvier that the formative organ of the feather commences from a dermal papilla, though itself not a dermal papilla as taught by Dutrochet, it may be admitted, as stated by the latter writer, to be covered with skin or epidermis, and is then in precisely the same condition as a hair is when it cannot readily penetrate the cuticle, but, as Weber says, raises it and forms a little knot or hillock till it at last bursts through. This germ or bulb, as it may justly be called, continues growing till it projects upon the surface of the body, ensheathed in the epidermal case, which acquires a corresponding size and form, viz., that of a cylinder with a conical extremity, consisting, as Cuvier states, of a very soft, fibrous and yellowish membrane at its lower part, but becoming whitish, opaque, soft, and of an almost cartilaginous appearance towards the tip, which, as it becomes exposed to the air, dries, hardens, and is converted into more or less numerous delicate, transparent, cuticular layers. If this sheath be opened, the bulb itself may be seen, its base attached to a small aperture in the base of the bulb, through which the blood-vessels and nerves are admitted to it; and from around this point, commencing at the hind part, arise a number of delicate plates, corresponding to the sensible or secreting plates in hoofs, each pair of which, after the hindmost are formed, rise up obliquely forward and meet in a mesial line, which extends along the whole length of the front of the bulb, their edges being slightly connected with the inside of the sheath, and tearing away as that is turned back, leave the appearance to which Cuvier has applied the name *external striated membrane*. In the very narrow and obliquely winding grooves thus formed is the soft dark matter deposited which, when dry, becomes the barbs of the vanes. At first there is no appearance of stem, but as the barbs are perfected, their little stems which are horny being produced, the bulb forms the hind and fore part of the top of the stem of the feather itself. So soon as the upper extremity or tip of both barbs and stem are formed, it presses against the free end of the sheath, bursts it, and protruding quickly dries, and the barbs escaping from their narrow sheaths, the plates which had divided them fall off together with the dried sheath, and the protruded part is perfected. The growth of the feather is still continuing, and the upper end of the bulb being in great activity, throws out the spongy substance in the interior of the stem, and separating its anterior and posterior plates, which had first been approximated, gives the stem its squarish shape, and this continues growing thicker and thicker as the protrusion of the feather widens the aperture of the sheath, which being no longer required, as it is projected drops down in skinny rings about its orifice. The growth of the barbs from the ring where the vessels enter continues till they meet in front, when it ceases, and in proportion as they have risen up from the bottom of the bulb, the barrel of the feather has been progressing in its formation from the bulb, which having now no other duty to perform, quickly produces the horny cylinder, and its vessels contracting from the upper part continue so doing till they reach the base of the bulb, where they become obliterated, and the bulb itself shrivels up and assumes the form of a succession of skinny-like caps, which are connected at top with the depression in front of the bottom of the stem whence the last short pair of barbs are given off, and from their hair-like appearance indicate the diminished vital powers of the tip of the bulb, whilst at the bottom, as it approaches the navel, the shrivelled bulb remains much more bulky than in other parts, and is fixed to and fills up that aperture.

After the perfect development of the feathers they remain fixed in their sockets in the skin and hide, to which, without being organised, or at least having but a very low degree of vitality, they are connected in a somewhat similar manner to that of the connection of the teeth with the membrane of the gums, and so remain till the time of moulting, when their attachment becomes loosened and at last they fall out, not however till they have led the feathers which are to succeed them into the cavities they are about to vacate, in precisely the same way as the first plumage had been brought through by the down with which the bird had been first clad.

In all the modifications of the dermal tissue hitherto considered, their horny product, either plate, nail, horn, hair, or feather, has been exterior to the structure by which they have been produced, and they have consequently overspread a larger or smaller surface of the hide in place of the skin or cuticle which has been there deficient, as it merely overlapped the margins of plates and nails, which seem to be only set into the skin like a watch-glass within its containing ring, for the purpose of strengthening their connection with the subjacent hide. In like manner also the skin rises up and forms a sort of ring around the lower part of hair or feather with the same object. In either case the skinny lip or ring gradually attenuates and is speedily lost; it cannot therefore be considered as giving any covering to these horny products. In the modification of horn, to be next considered, there is, however, a remarkable difference from that arrangement, the part produced being, on the contrary, contained as it were within a sheath of that which produces it. Such is the case with

### *k.* Scales, *Squamæ*,

Which are as specially the covering of fishes as feathers are that of birds. The scales improperly so called of

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certain beasts, birds, and reptiles, being, as already mentioned, merely larger or smaller plates of skin, which are either flat upon the surface of the hide, or envelope processes which it puts forth, of greater or less size, but always contained within the horny matter, and therefore entirely differing from true scales.

Before describing the scales of fish, it will be necessary to make a few observations on their general mode of arrangement. Immediately behind the aperture of the gill, a row of scales is connected with the skin, nearly vertically as regards the body, with the upper and lower edge of each in contact with the lower and upper edge of those nearest it in the same vertical rank; this connection does not extend throughout the whole length of the scales, as their hinder edge is either angular or forming an arc of a circle, consequently between the hinder extremities of every two scales there is a more or less angular gap. From within and behind this row projects backwards the second row, which are interposed between the tips of the former and the hide. Now if the longitudinal connections of each successive row of scales were in the same line, there would be throughout the whole length of the body as many seams as there are horizontal ranks of scales, which would not only be useless in reference to the protection the scales are intended to give, but also materially interfere with the animal's motions. The disposition is, however, very different. The longitudinal junction of the succeeding row takes place behind the middle of each scale in the row preceding it, so that the tips of the scales of the first row are not merely received into the gaps between each two of the second row, but even reach further back and overlap the centres of the scales of the third row, each of which, as are those of every succeeding row, is covered partially by three scales, most largely by the two in the immediately preceding row, which join by their edges, and in a slight degree by the tip of that which overlaps the junction of the two just named. In this way the junctions of the scales with each other and their attachment by their front ends to the hide is entirely concealed, in precisely the same way as the roof of a house is covered with flat tiles or slates; and it is impossible to reach the hide without penetrating two or three scales, except the thrust be made obliquely between the rows and from behind.

Leeuwenhoek, who was the first careful examiner of the structure of scales, has given a tolerably faithful account of the mode in which, as will be presently described, each scale is contained in a membranous sheath, and he has justly observed that there is a difference in the covering of parts of the same scale; that the exposed hind extremity only is closely covered with a membrane or cuticle, as he calls it, which he considers made up of a network of most minute and delicate vessels, partly arising from the cutis or hide, and partly from the neighbouring scales, whilst the rest of the scale which is concealed exhibits no such cuticle, but is unattached. He states that this cuticle, which had been previously called *fæx* or *phlegma*, is not extraneous, but is really a part of the body, " and none other than little veins interwoven with each other, which are of almost incredible delicacy, and consisting of an incomprehensible and immense number of branches."* And he busied himself in endeavouring " to discover vessels in scales by which these feculent vessels are formed."* For this purpose he examined the scales of the bream and found them to consist of a transparent crystal, disposed externally and internally in ridges, of which, counting from the centre to the circumference of the scale, he found more than two hundred, connected together " by innumerable delicate striæ, or, as it might be better expressed, vessels intermingled and surrounding each other." These could be split, and layer under layer readily found in the thickness of the scale, all of precisely the same figure, but each increasing in size as they were later formed and consequently approached nearer the inner surface of the scale. Of these layers in a scale as big as a dollar, which he took from an enormous carp of three feet and a half in length, Leeuwenhoek counted forty, and he then considered each layer as being an annual growth, and that therefore the carp was as many years old, presuming that, in support of this notion, he might use the analogy not only of the annual rings of timber, but also of those on the horns of oxen.†

In 1716, Reaumur, in his account of the *Essence d'Orient* employed in the manufacture of mock pearls,‡ and consisting of the silvery matter washed from the scales of the bleak, (*Leuciscus Alburnus*, Cuv.) speaks of this colouring matter as being contained in vessels, or a sort of pipes running along the length of the scales, from both ends of which it could be squeezed out by pressure in the middle. His description of these colour-holding tubes, which are really no other than the spaces between the fibres of the scale, is far from correct, but he accurately points out that the centre from which the concentric rings of the scale spring is not in the centre of the scale itself; and he also notes the minute apertures in those scales which form the *lateral lines* of fishes, and which give exit to the mucous secretion with which their surface is overspread.

If the scales of a carp (most convenient on account of their large size) be examined, it is easily perceived that they are contained in soft sheaths, from which they can be displaced without much difficulty; and it may be observed here as a general rule that the attachment of the scales is proportionally strong as the fish lives near the shore or in deeper water. Each scale is inclosed in a closely-fitting sheath, composed of a doubling of the hide, which becomes very delicate and thin for that purpose; but the scales are so arranged that a large portion of the anterior outer part of each sheath forms the posterior inner part of the adjoining halves of the sheaths of the two preceding scales by which it is overlapped; whilst the covering of its own hinder and inner part covers a corresponding portion of the adjoining halves of the two following scales which it overlaps; and thus, if all the scales be removed from the body, corresponding shreds of this thin hide are seen, giving the surface a ragged appearance. The sheath is not attached with equal firmness over all parts of the scale; it is most intimately connected with all that part of its hinder external surface which stretches beyond the row of scales preceding it, in which the colouring pigment is deposited, and it is here extremely thin; it is

* See his *Opera Omnia, seu Arcana Naturæ*, vol. i. p. 105.

* See *loc. cit.* p. 108.

† See *Op. cit.* vol. iv. p. 213.

‡ See his *Observations sur la Matière qui colore les Perles fausses et sur quelques autres Matières Animales d'une semblable couleur; à l'occasion de quoi on essaye d'expliquer la Formation des Ecailles des Poissons*, in *Mém. de l'Acad. Royale des Sciences*, 1716, p. 229.

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also firmly connected on the inner side of this end of the scale (though less so than externally) as far forward as the centre of the converging circles to be hereafter mentioned. Here also pigment is found, together with the shining silvery matter which overspreads the inner surface of all scales. In front of this centre the outer surface of the scale has but little connection with the sheath, but within, if it be gently raised from its bed, numerous very delicate threads may be seen passing from the subjacent hide, which is here quite white: these threads are doubtless the secreting apparatus of the scale itself, and can be seen as far as the marginal boundaries of the sheath. When the sheath is cut open, lengthways, without disturbing the scale, its formation and different thickness are very apparent; the whole of the anterior outer surface consists of a process given off from the hide, which is thick and white and loosely connected with the scale so far as the centre, behind which it thius extremely, becomes coloured with pigment, and is so intimately attached to the scale that it cannot be entirely removed; it reaches rather beyond the hind margin of the scale, and then, reverting inwards and forwards, first forms a delicate fringe to the edge of the scale, and then again thickening, fixes itself firmly to the inside behind the centre, and there subsides into the hide itself, which forms the rest of the inside of the sheath, from the centre to the front edge of the scale. The sheath may therefore be not inaptly compared to two pieces of paper of unequal breadth, joined together by their longest edges: the widest piece represents the outer, and the narrow the inner part of the sheath, and the deficient part is that occupied by the hide itself. That part of the sheath which is white, thick, and covering the anterior outer part of the scale, is very elastic: it allows the scale to be pulled out to a slight extent from those by which it is covered; but when the scale is set free, it immediately brings it back to its original place, and indeed does not prevent it being thrust still further in, but so soon as the pressure is removed, it again pushes it into its proper situation. It is therefore of great importance in the motions of the body, as, by allowing the scales to glide upon one another, it enables them to overlap still more when the body is rendered concave on their side, and permits them, on the contrary, to be separated from each other when the body is rendered convex, both of which curves it necessarily is continually making as the animal is sculled along by the lateral motion of the tail.

The scale itself, when removed from its sheath, is found to be a horny plate, more or less vaulted within and correspondently elevated without. Its shape is very variable in different fishes, angular, oval, or round, or modifications of one or more of these forms. It exhibits a central and more dense point, which is the part where cornification commences; it is not, however, in the centre of the scale, but much nearer to its hind edge. From this point rays are extended to the margin of the scale, and when the latter has an angular form, the rays which pass to the angles are most distinctly developed. Around the point concentric threads extend, which are closer to each other as they are nearer the point, and more distant from each other as they approach the margin; they connect the rays together, and the whole may be compared not inaptly to the web of a spider. All that part of the scale which is in front of the central point, and covered by the overlapping scales, is highly transparent and glasslike, but the rest, which is behind it and which is uncovered, is coloured by the pigment externally, which can, however, be, with some little trouble, detached from it; the inner surface is not so coloured, the silvery matter being easily wiped off.



Each scale, as Leeuwenhoek has stated, can be split into layers, of which the smallest and outermost is that where the central point exists, whilst the margin of the scale is formed by the last formed and innermost layer, the scale there being extremely transparent, thin, and flexible.

The principal constituent of fish-scale is horn, but it is distinguished from the so-called scales on the legs of the turtle family, in having phosphate of lime interposed between its layers and threads; the quantity of course varies in proportion to the toughness of the scales, being most when they are hard and unyielding, and least when they are soft and flexible.

Little has hitherto been done with reference to the growth of scales. Leeuwenhoek thought he could distinguish the little original scale, as the smallest layer of the forty-plate carp scale he had the opportunity of dissecting, and he says that all scales grow from their under or inner surface. This notion is doubtless correct, if the growth of scale have analogy to that of other horny productions, of which there can be no doubt. It is therefore probable that the growth of the scale is taking place most actively, at least where it is most closely connected with its sheath, and this is over its entire inner surface, and upon all that part of its exterior which is behind the central point. What the arrangement may be by which the diverging and concentric threads are produced is not yet ascertained, but it may reasonably be supposed that both are merely casts of the disposition of the papillæ of the hide, as the ridges of the skin are in the human subject. It is also not unlikely that the vessels which supply the hind and overlapped part of the scale, are continued from the hide along the partition which separates the sheaths of the scales by which it is overlapped, and that these secrete the pigment or colouring matter of the scale; whilst the inner binder part has its peculiar silvery matter produced by another set of vessels which come more directly from the hide itself.

The other so called scales of fishes which do not overlap, but are covered in the same manner as true scales, and probably also similarly formed, as the very minute scales of the eels, blennies, and others, which are largely overspread with mucus, seem to make the transition from the scales of fish to the horny scale-like plates of reptiles and birds.

In all the preceding modifications of the secretion from the *Dermal Tissue*, (excepting scales,) from its most simple form, skin, to its most complicated arrangement, feather, none other substance has been found to exist but horn. In those teguments, however, which remain to be considered, a very marked difference appears in the presence, in some cases, of a peculiar matter resembling, though not really, horn, and in others of calcareous earths, by the latter of which the animal covering attains in many instances an almost stony hardness.

### l. *Chitonous Tegument.*

The external covering of insects appears to be a horny case, varying in firmness and brittleness, in softness and flexibility, in different orders and kinds, and, even in the same insect, at different periods of its existence. Bur-

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Zoology. meister* describes it as "displaying considerable conformity with the skin in general, (the common tegument of the higher animals,) like it consisting of three layers." The true hide, the deepest, is distinguished by its want of colour, and by its peculiar structure, which consists of layers of crossing fibres, forming a light tissue and capable of separation into layers, of which Straus Durckheim distinguishes sometimes three, sometimes five, separated, according to Burmeister, by delicate canals, through which the formative juices seem to flow, when the still short and small wing-cases of a newly developed beetle begin to distend themselves. The outer superficial layer corresponds to the skin or cuticle, is smooth, shining, and textureless, generally transparent, and largely perforated with holes for the passage of hairs, which have their roots in the hide. It is easily separated in recent insects from the coloured mucous body beneath. This latter has, according to Straus, a very remarkable disposition, being found sometimes, as in coleopterous insects, divided into two layers, which are distinguished by their chemical properties as well as by their situation. The one forms a very delicate layer, overspreading the whole body, closely connected with the skin, but incapable of detachment in plates on account of its delicacy; although it may be removed by gentle scraping,† is soluble in spirits of wine, and is well characterized by its colour, especially in those insects which exhibit brilliant tints. The other part of this colouring matter is insoluble in alcohol, is generally brown or black, and never exhibits bright colours, as green, blue, red, or yellow, and is never found on the surface of the animal, but is contained in the very tissue of the skin and hide, and more especially in the former. At other times, however, as in the dragon-flies and locusts, this colouring matter forms a very thick layer beneath the hide, in which case both the latter and the skin are transparent as glass. In the course of their growth and their progress from the larvæ to the perfect state, insects shed their skin, as may be easily observed in the silkworm; but Straus observes that he knows but of one genus, the *Ephemera*, which changes its coat after having obtained wings, *i. e.* after arriving at its perfect state.

*Chemical composition.*—Till within the last twenty years, the tegument of insects was considered horny; but even lately, Burmeister says "it agrees in general with the chemical composition of horn, but nevertheless is distinguished by some peculiarities of proportion, which may probably arise from its being formed not merely by the epidermis (skin) alone, but by the entire cutis (hide)." The analysis of the wing-cases and wings of the cockchafer, given by Lassaigne to Straus, shows, however, that both by boiling in water and in a solution of caustic potass, a brownish matter was obtained, which was precipitable by acids, by infusion of galls, by acetate of lead, &c., but which would not gelatinize with water, and corresponded with the animal matter obtained from the cochineal insect, and others of its family, to which Lassaigne had given the name *Coccine*. This treatment, however, did not destroy the wing-cases, which still retained their original form, but became nearly colourless, transparent, and slightly flexible, like the wings of a fly. This base of the wings and wing-cases was distinguished from gelatine by its insolubility in boiling water, and from mucus by its not dissolving in caustic potass; and as at that time it had been only found in insects, Lassaigne called it *Entomeiline*. He also obtained, by calcining a hundred parts of wing-cases in a platina crucible, fifteen of a white ash, which consisted of phosphate of lime, and phosphate of magnesia. The membranous parts of the wings differed only in containing a larger quantity of *Entomeiline*.* Very shortly after the publication of Lassaigne's analysis, the subject was taken up by Odier,† who also found the same substance, which he called *chitine*, in the wing-cases of the same insect, (the cockchafer,) by treating them repeatedly with a hot solution of caustic potass, until all action ceased, when they became colourless, transparent like thin horn, and lost nearly three-fourths of their original weight, but without any alteration in their form. "During the action of the alkali," he states, "a slight disengagement of ammonia was perceptible, as happens in all solutions of animal substances in potass." This transparent matter is the chitine, insoluble in the solution of potass; it does not become yellow by the action of nitric acid, although it dissolves in it when digested with heat, and it burns without fusing, leaving a coal, which retains the original form of the part operated on, but in combustion it does not, according to Odier, give off any carbonate of ammonia, as he found litmus paper, previously reddened by acid, and held over the glass tube in which the chitine was burnt, did not recover its blue colour, as it would have done had any ammonia been disengaged. He therefore concluded that it possesses no nitrogen, and that no doubt of its vegetable nature could remain. He considers it to resemble *lignin* or woody fibre, and observes, "it is very remarkable we should thus find in the frame work of insects the same substance that forms that of vegetables, or which at least approaches it in many of its characters." Mr. Children,‡ however, proved by experiment, that chitine does contain nitrogen, and has detailed the results of two experiments. Having procured this substance from powdered cantharides, by treating it for many days with caustic potass, and subsequently washing and drying it at a heat of 212°, he burnt it in green glass tubes with protoxide of copper, having some clean copper filings above the mixture, and over it some perfectly dry amianthus in Cooper's apparatus, first employing a very gentle heat, which was gradually raised till that part of the tube containing the chitine was bright red hot, and the gas had ceased to come over. The kinds and volumes of gases were then ascertained, and he found in the first experiment with 2·072 grains of the pure chitine the following results:—

| | | | |
|---|---|---|---|
| Carbon | 0·962 grains, or per cent. | | 46·43 grains |
| Hydrogen | 0·129 | " | 6·22 |
| Nitrogen | 0·239 | " | 11·05 |
| Oxygen | 0·742 | " | 35·81 |
| | 2·072 | | 99·51 |

* See his *Entomologie*.

† See his *Considérations générales sur l'Anatomie Comparée des Animaux Articulés*, p. 26, *et infra*.

* See Straus, *loc. cit.* p. 33.

† See his *Mémoire sur la Composition Chimique des Parties Cornées des Insectes*, in *Mémoires de la Société d'Histoire Naturelle de Paris*, vol. i. p. 101.

‡ See his *Remarks on Odier's Paper* in *Zoological Journal*, vol. i. p. 111.

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And in the second experiment with 4·75 grains of the same chitine:—

| | | | |
|---|---|---|---|
| Carbon | 1·500 grains, or per cent. | | 45·73 grains |
| Hydrogen | 0·187 | " | 5·70 |
| Nitrogen | 0·313 | " | 9·54 |
| Oxygen | 1·280 | " | 39·02 |
| | 3·280 | | 99·99 |

In another experiment which he made with a mixture of chitine from *Silpha Obscura*, a carnivorous insect, *Geotrupes Stercorarius*, a dung-eater, and *Cetonia Aurata*, a vegetable feeder, burnt with peroxyde of copper, to ascertain the quality of the gases produced, 18 cubic inches were collected, which, after the action of potass, left 1·35 cubic inches of nitrogen. "Consequently," says Mr. Children, "M. Odier's conclusion that it (chitine) rather belongs to the vegetable than the animal kingdom is erroneous."

As regards the other materials found in the wing-cases of the cockchafer, Odier found, by infusing them repeatedly for some hours in cold water, that the latter became slightly yellow, and rather less fluid, and when evaporated to dryness, with a gentle heat, left 0·6176 grains of a substance consisting of extractive matter, and a little coagulated albumen: this, on calcination, exhibited carbonate of potass, the presence of which distinguishes the tegument of insects from that of crustaceans. Another portion of the wing-case having been frequently treated with alcohol, and the solution evaporated, some small drops of a brown oil were obtained, from which water took up a brown extractive matter like that found in the aqueous solution, together with a substance of a sensibly alkaline taste, by means of which a little fatty matter had been dissolved, which separated by adding muriatic acid, occasioning with it a slight effervescence. This liquid, evaporated and calcined, gave, upon the addition of muriate of platina, a yellow precipitate, the muriate of potass; hence the carbonate of potass found in the aqueous solution. Besides these salts, Children found in the canthrides a small portion of silica and magnesia, and a slight trace of manganese; and Burmeister says there are also traces of phosphate of iron. As to the brown oil, mentioned by Odier, it seems most probable that upon it depends to a certain extent the colour of the insect tegument, for Lassaigne states that *Crioceris Merdigera*, treated with alcohol, affords a red oil, which is still more beautiful if æther be employed. Robiquet also obtained from cantharides, similarly treated, a fine green oil resembling their colour.

The albumen, Burmeister considers, as is doubtless the case, to belong to the hide, and the brown colouring matter to the so called mucous body, "to which also he attributes the chitine, whereby the true horny skin, viz. the epidermis, will be found to agree entirely with the horns of the higher animals."

### *m.* Shells, *Testæ*.

Many molluscous animals have their soft body protected from injury by plates or tubes, in which they are more or less fully developed; to the former the name *valve* is applied, and of these a mollusc may have but one, when it is called a *univalve*, or two, and be a *bivalve*, or more, and be *multivalve*: to the latter, which consist only of a single tube, variously twisted, the term *tubular*, or *conch-like shell*, may be applied. The structure and composition of all is, however, generally alike. Various writers have occupied themselves in examining the nature of these very beautiful structures, among whom must be mentioned Reaumur, who held that they were entirely destitute of organic structure. He supposed the growth of the shell to be effected by a very tenacious mucus, loaded with calcareous particles, which abounding largely in the substance of the mollusc, was poured forth on every side through the pores of the cloak, and, conveniently inspissating, was converted into shell; in the same manner as springs of water often deposit calcareous crusts on wood, branches of plants, &c., and that layer after layer was deposited on the outer surface, till the shell had attained its proper density and thickness.* This statement of Reaumur was, however, in the latter end of the last century, entirely disproved by Poli in his noble work, *Testaceæ utriusque Siciliæ eorumque Historia et Anatome*, who showed distinctly that shell is an organic structure, and that, instead of increasing by the addition of external layers, it actually grows by the deposition of successive layers on the inside of the shell, produced by the animal itself. The subject has not been more fully nor ably treated by any later writer, and therefore from his work the following digest on the structure and growth of shell has been taken.

When the earthy matter has been removed from a shell by immersion in a solution of nitric acid, with four parts of water, a great effervescence takes place, much gas is evolved, and the calcareous earth being dissolved, numerous layers of membranes, one upon another, are found, which are so extremely elastic, that if raised with the forceps and suddenly let go, they not only recover their original form, but even roll up together. Poli finds that these membranes exhibit four kinds among the vast varieties of shells which he examined: 1. Such as differ little from expanded cellular tissue, on the surface of which are innumerable and close-set hollow points, as seen in *Lepas Anatifer*. 2. Such as have the expanded layer of cellular tissue supplied with numerous regularly arranged vessels, distributed in very elegant circles, as in *Tellina Nitida*. 3. Such as, though seeming to consist of very simple cellular tissue, are not flat, like the former, but disposed in carinated, or large subcylindrical folds, which are sometimes even dichotomous, as in *Patella Cærulea*. 4. Such as have the membrane completely retiform: these under the microscope appear to consist of vertically disposed lamellæ, of which the upper edge seems to form the base and support of the numerous delicate vessels everywhere accompanying it, as in *Pinna Muricata* and *Nobilis*; the peripheries of these areoles vary in shape, sometimes they are triangular, rarely quadrilateral, heptagonal, or octagonal; most commonly pentagonal or hexagonal; but all are equilateral and equiangular.

All membranes of this kind are immediately derived from the body of the mollusc, and, as it were, continue and send its substance and vital powers into the shell, which thus penetrate every where. Their animal character is proved by combustion, when they give out the smell of burnt horn or dried bladder, and are converted into a spongy charcoal. The membranes are every

* See his *Mémoire de la Formation et de l'Accroissement des Coquilles, &c.*, in *Mém. de l'Acad. Roy. des Sciences*, 1709, p. 364.



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where filled with particles of calcareous earth, so disposed that each membrane, with its earthy particles, forms a testaceous plate; and by a series of these, placed one upon another, is the shell formed. The earthy matter is not deposited at hap-hazard, but regularly in form of crystals, which sometimes assume a lamellar, and sometimes a columnar form. In *Pinna* they are columnar, subpellucid, and very little dissimilar to pure chrystal, are deposited in the areolea of the reticular membrane, and connected and strengthened by its plates. And as these areoles vary in shape, so also do the sides of the columns, and hence they are prismatic, or parallelopiped; pentagonal or hexagonal; and some even heptagonal or octagonal. In the *Buccinum Galeum*, and similar shells, the chrystals are deposited in plates, and are less transparent, and are supposed to be situated in the cellular tissue, which they invest, whether flat or plicated. The constituent principles of both kinds of chrystals are the same, but it is upon their various proportion in different kinds of shells, that the consistence of the latter depends. And hence, when the chrystals contained in a shell are very pellucid, the animal net or retiform membrane is seen without any preparation. It is very remarkable that the Malpighian net, or pigment, more properly speaking, exists in this animal net, just as it does in man: in such shells therefore as have their earthy particles pellucid, the colours of the animal net existing in the several testaceous layers are seen through, and are so vivid, that if the earthy particles be removed, and the cellular net spread on glass, they are beautifully seen without a microscope; but in those which have the earthy particles opaque, the colours show very coarse and dull.

*Growth.*—If the valves of a bivalve shell be slightly separated, it will be readily seen the cloak or mantle, as it is called, of the contained animal, overspreads the whole of their interior, and that its *limbus* or edge, rather flattened, but able to be curved at the animal's will, extends beyond the margins of the valves. It is therefore not difficult to imagine that, when the period approaches for the growth of the shell, the extremely delicate plates from the membrane of the cloak, where opposite the disc of the shell, spontaneously separate, and being filled with earthy particles from a peculiar organ, produce testaceous plates, and are very firmly connected to the valves. These testaceous additions are at first entirely membranous, and sometimes appear as torn and pendulous from the shells themselves; but each addition always proceeds from the margin of the ligament, or from the part where the cloak is given off from the body of the mollusc, and corresponds most accurately to the shape of the cloak itself, nor is it formed beyond the extent to which the cloak can be stretched. It is further to be observed that in some shells, especially in bivalves, the testaceous additions sometimes present themselves on those parts of the shell covered by the cloak; those which are occupied by muscles, adductors, orbicular, or others of the same kind, are devoid of the common increase of the shell, so that a little pit is there formed, which seems to be surrounded by the limits of the additions; this may be observed in *Mya Pictorum*. From these valves which it lines, the cloak of the mollusc, gradually protruding, projects itself beyond the margins of the shell to form plates, membranous at first, but subsequently becoming loaded with testaceous matter.

The testaceous plates are extremely delicate, and the first of all, or most external, arises exactly from the region of the umbo, or from the apices of the shell, and lies over all the others; that which lies beneath it is on every side more dilated, increases both the thickness and size of the shell, and the subjacent ones continue so doing. The beginnings or roots of each plate, lying in both regions of the umbo, seem therefore to be produced forwards from the umbo itself by regular steps, so that the upper and smallest layers of all are seen to burst forth, as it may be said from the centre of the umbos; but the lowest and widest derive their origin from the margins of the ligament; the others occupy the intermediate space, accurately marking the progress of the cloak at different times of life; the shell, therefore, emerges thickish around the region of the umbo, but gradually thins towards the edge. Every shell therefore consists of innumerable others of gradually increasing size, regularly received into one another, each produced by its own proper mollusc, and never subsequently capable of increase, the animal membranes, already mentioned, being most closely connected every where with earthy particles. It is thought, however, that the membranes are nourished by the muscles of the mollusc, as their tendons are so fixed in the substance of the shell, that, however great the force used, they are torn to pieces rather than detached. The extension also of vessels from the adductor muscles is shown by the fact of mercury, which had been injected by the aorta, escaping from the mouths of the vessels of such parts of the muscle as had detached themselves from the shell, when immersed in spirit of wine, of their own accord. Turbinated shells grow in precisely the same way, the increase taking place from the aperture of the mouth or edge of the lips, whence a new membrane is first protruded, which may be well seen in *Helix Picta*, in which the previous size of the shell is shown by the rosy lines running along the edge of the lip. The growth of the shell is not perennial, but at stated times, as may be well seen in the oyster and in the common snail. At the conclusion of summer, when the rains commence, the snail, which had previously remained firmly attached to the stems of plants or the trunks of trees, in consequence of the dryness of the air, or had been hid in a hole, comes out into the warmth, and puts out new membranes, which soon harden, and are successively produced at intervals of a few days, depending on the greater or less moisture of the weather, till they have acquired considerably increased size; and this continues till the beginning of the following June, when the process is suspended till the return of autumn.

The upper or outer part of every shell is covered with its own proper tunic, which may be called the *crust*: this, when first examined, resembles a very beautiful layer of calcareous spar, but when separated with a steel point, as it may easily be, it closely resembles the fibres of asbestos, and if further examined with a microscope exhibits an elegant series of regular chrystals, very clear, and pervious to the light, and as to nature, form, &c., by no means dissimilar to those of which the testaceous plates consist, excepting only that they are far less coherent. They are implanted in bundles, vertically, upon every part of the subjacent tunic of the shell, and cover them like the shell of a tortoise. The crust is sometimes highly polished, sometimes scabrous, sometimes curly, and hence the various appearance of the exterior of the shell.

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Finally, this crust, and therefore the exterior of the whole shell, is overspread with a common tegument, called by conchologists the *Epidermis*, which is of very varied form, most commonly a simple membrane, either thin or thick, polished or curly, which under the microscope exhibits branching vessels or fibrils; is sometimes hairy or woolly, sometimes exhibits broad plates with ciliated edges. It may be as well here to notice (although perhaps not actually in place) that Poli considers it indisputable, as Reaumur had previously conjectured, that although the muscles of shells, as already mentioned, are so closely connected to their interior, that it is impossible to separate without cutting through them, yet are the animals so constituted that, at stated periods, the muscles spontaneously separate from the shells, and spreading and extending themselves still further correspond to the growth of the shells. This, indeed, is highly probable, as the muscular mark in shells is found to be not equally flat, but in some degree retains the traces of its former growth, or, as it might be better expressed, the successive movement of the muscles from the umbo towards the margin of the shell is distinctly indicated by the successive, regular and very delicate elevations of the plates—in which it is equally worthy of notice, that the first of these traces are observed to be gradually filled up and obliterated by new layers, being superposed, and, as it is said, completing the substance of the shell. Having already stated that the material constituting the fabric of the shell is transfused from the body of the mollusc, according to the course of circulation, into the membrane of the cloak, and that from thence the testaceous layers are elaborated, Poli observes, that it is further necessary to show that this kind of calcareous juice is produced in a peculiar viscus, situated most commonly a little beyond the heart, near the upper adductor muscle; sometimes, however, it extends along the back of the mollusc, and, dividing into two lobes, surrounds the heart. It is the singular organ which Cuvier mentions* as surrounding the pericardium of the slug and snail, existing under other forms in many molluscs, and to which he applies the name *secreting organ of the viscosity*, and describes it as a triangular bag, the interior of which is filled by a vast number of very delicate plates, which join by their edges to its walls and to one another, and from whence an excretory canal passes to terminate at the edge of the respiratory hole. According to microscopic observation, it consists of follicles or innumerable, most minute acinules, closely connected and very largely interwoven with numerous vessels, forming a very remarkable net-work. That this organ is for the purpose of providing the calcareous matter, Poli is led decidedly to conjecture, from the material of the shelly growth being very largely contained in this viscus in several molluscs, as in *Venus Chione*, *Arca Pilosa*, and *Pinna Muricata*, in which even the colour corresponds to that of the shell: thus in the two former it is white, and in the latter pomegranate coloured; it effervesces also with acid, and becomes extremely hard when dry. It is from this matter, inspissated by decay, disease, adhesion, or any other cause, that pearly growths are formed, and which are found in the course of the circulation, not only in the duplicature of the cloak, but even in the peritoneum, pericardium, and ovary. Occasionally it happens that some of these growths, from the organic tunics supervening, are not stretched out as usual, but form certain exostoses, or kinds of wart, which occasionally adhere to the shell or leave it after a time; these, when they resemble the silvery colour and resplendence of the shell, are said to be *pearls*.

*Colour.*—The interior of shell is sometimes coloured to a greater or less extent, and more or less deeply of a yellowish or brownish colour, which Blainville considers to depend on its contact with the liver. But the pearly iridescent appearance is very different from this, and arises, according to Brewster, from the mechanical disposition of the molecules, and not from the colouring matter.

The colour, however, of the exterior of the shell depends on the existence of pigment, which Reaumur has proved by experiment to be produced by the anterior edge of the mantle;* for in *Helix Nemoralis*, which is banded with black on a yellow ground, he observed that that part of the collar (or edge of the cloak at the orifice of the shell) corresponding to the black bands, exhibited the same colour, so that if a piece of the edge of the shell were broken off, the portion reproduced was black opposite the black part of the collar, and yellow elsewhere. It is also to be remembered, in support of Reaumur's assertion, that if by any accident the shell be broken at a distance behind the edge of the mantle, although it is repaired by the secretion of pearly matter from the surface of the corresponding part of the cloak, yet no colour is produced. Light has also doubtless an influence in the development of the colours of shell: thus in many bivalve shells, the under fixed valve is white or light coloured, whilst the upper one is very brightly tinted, as may be seen in many of the scallops. Olivi has also observed that shells which are overspread with sponges or alcyons, or which live in mud, or in continually shady places, are much paler than those which are exposed to light.

*Chemical characters.*—Poli has given in his great work a chemical analysis of the shell of *Pinna Muricata*, from the red part of which he obtained calcareous earth, resinous gluten, carbonic acid gas, and oxide of iron. The pearly part contained, in addition to these, a quantity of magnesia, and an odorous resin, which, infused in spirits of wine, became milky, on the addition of alkali. The epidermis yielded oily gluten, with a very small quantity of iron, and a very small quantity of calcareous earth. When the shell had been subjected to destructive distillation, a coal was left, which consisted of animal gluten, calcareous earth, a small quantity of iron, carbonic acid, and sulphuretted hydrogen gas. Mr. Hatchett† also examined the composition of shell, and no better analysis than his has been since given. He divides shells into two kinds, 1. Those of porcelainous aspect, with enamelled surface, and appearing slightly fibrous when fractured. 2. Such as have a stony epidermis, beneath which the shell principally or entirely is composed of *nacre*, or mother-of-pearl. The porcelainous shells, of which he chose *Volutæ* and *Cypreæ*, in a red heat lost their colour, and became opaque white tinged with grey, but retained some of their gloss. They did not emit any apparent smoke, nor smell like burnt horn; they crackled, but their figure remained unchanged, excepting a few flaws. When thus burnt, they were dissolved, and deposited a very small quantity

* See his *Mémoire sur la Limace et le Colimaçon*, p. 26

* See Reaumur, *loc. cit.* p. 391.

† See his *Experiments and Observations on Shell and Bone*, in *Phil. Trans.* 1799, p. 316.



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of animal coal, thereby indicating the existence of gluten, although in so small quantity, that in solutions of the unburnt shell it could not be detected. In both solutions, by the addition of carbonate of ammonia, he found carbonate of lime, but other tests did not find any phosphate. He therefore determined that porcelainous shells consist of carbonate of lime, cemented with a very small portion of animal gluten. Nacrous shells, as exemplified by the oyster, when exposed to a red heat, gave out a perceptible smell like burnt horn; in solution they exhibited a larger quantity of coal than the porcelainous, and the carbonate of lime in them was proportionally less, but the figure of the shell was not retained, nor did it exhibit any fibrous character. The unburnt shell of a species of fresh water mussel, exposed to dilute nitric acid, at first gave off largely carbonic acid gas, and at the end of two days, nearly all the carbonate of lime was dissolved, leaving, however, a series of membranes retaining the figure of the shell. He states also that each membrane has a corresponding coat or crust of carbonate of lime, so situated that it is always between two membranes. The wavy appearance and iridescence of nacre he considers to be dependent upon its lamellate structure and semitransparency.

*n.* Calcareous Crusts.

The tegument of the whole class of crustaceous and many of the radiated animals is remarkable for the large quantity of calcareous matter which is deposited in the chitonous layer produced by the hide; and which are together thrown off periodically by the former class of animals, as is well known to be the case with the common lobster. This shedding of the crust is necessary to admit the growth of the animal, which, whilst the crust is fully developed, cannot enlarge its proportions; but to compensate this restriction it grows very rapidly between the time of the casting of the crust, and that when the new crust has acquired its proper density by the deposition of calcareous matter, probably between plates of chitine, in the same way as the growth of shell is effected. Milne Edwards* says, that to form a correct idea of the structure of the tegument of crustaceans, it must be examined at the time they cast their shell, and he describes it as consisting of three principal membranous layers. The deepest layer resembles the serous membranes of the higher animals; it is scarcely visible on the limbs, but very distinct around the large cavities into which it enters and invests the viscera; it is thin, transparent, and smooth on its inner surface, but rough externally, where connected with the middle membrane. From this description it seems pretty evident that it is no part of the tegument, but in reality only the serous peritoneal membrane, and that this middle layer is truly the deep layer of the tegument, the *chorion*, or hide, to which Edwards says it may be compared, and which it closely resembles by its softness, more or less sponginess, its thickness and great vascularity, as also by its external surface being generally coloured, and its functions, as justly stated by that writer, being the secretion of the outermost layer, the skin, or epidermis, which is a delicate, but dense and tough membrane, not exhibiting any vascular ramifications. The skin is only distinguishable immediately prior to the shedding of the shell, for very speedily after it acquires much greater consistence, in some genera becoming of a horny toughness, whilst in others it is encrusted with calcareous matter.

*Chemical characters.*—According to the observations of Mr. Hatchett,* on the crustaceous coverings of the crab, lobster, prawn, and crayfish, it appears that immersion of the shell in acetous, or in dilute nitric acid, afforded carbonate and phosphate of lime, the former, however, in largest quantity, leaving the shell soft and elastic, of a yellowish-white colour, and like a cartilage which retained its original figure; the colouring matter in both cases was soluble in alcohol. Chevreul's attention was also directed to this subject, and he gives the following analysis† of the

| | Common Lobster. | Black-clawed Crab. |
|---|---|---|
| Carbonate of lime | 47·26 | 62·80 |
| Phosphate of lime | 5·22 | 6·00 |
| Phosphate of magnesia and iron . . . | 1·20 | 1·00 |
| Chloruret of sodium and salts of soda . | 1·50 | 1·60 |

And it is worthy of remark, that among the salts of soda in the lobster, a small quantity of the hydriodate was distinctly recognized, which was not met with in the crawfish; a remarkable example, as Edwards observes, of the influence which the nature of its habitat has upon the chemical composition of the tegument of an animal. The absence of carbonate of potass, and the small quantity of phosphate of lime, are held by Odier to distinguish the shell of crustaceans from the covering of insects. Odier, in his paper *On the Corneous Parts of Insects*, already referred to, appears to have been the first who noticed the similarity between the animal part of the shells of crustaceans and chitine. He macerated for some days the shell of the common crab in water acidulated with muriatic acid, by which all the earthy parts were separated, leaving a soft, flexible substance disposed in laminæ, of a light brown colour, laid on each other, which became white by boiling in potass, but did not dissolve, was not coloured by nitric acid, and burnt without smelling. More recently Edwards has examined the shell of *Carcinus Menas*, and found in it also chitine, together with a small quantity of albumen, and a very large proportion of salts mingled with a little animal matter, soluble in weak hydrochloric acid.‡

The colour of the tegument in these animals depends upon the pigment secreted by the hide, as in other dermal tissues. Edwards compares it with that on the legs of pigeons, and the bills of geese, which it resembles in its softness, being like coloured paste. It varies in colour in different kinds of crustaceans, but is commonly brownish, greenish, or bluish. As is well known in many instances, it changes colour by boiling, as in the lobster, to a bright scarlet, and in the crayfish and crab to a dirty-red. But in others the colour remains unchanged. Lassaigne § has examined its chemical properties in the lobster, and gives the following account. A portion of the crust plunged in alcohol, at a temperature of 15° centigr., assumed a bright scarlet

* See his *Histoire Naturelle des Crustacés*, vol. i. p. 8.

* See *Phil. Trans.* 1799, p. 324.

† See Geoffroy St. Hilaire, *Troisième Mémoire sur l'Organisation des Insectes*, in *Journ. Compl. des Sciences Médic.* 1820.

‡ See *loc. cit.* vol. i. p. 10.

§ See his paper *Sur le Principe colorant des Ecrevisses et de quelques autres Crustacés*, in *Journal de Pharmacie*, vol. iv. p. 174.

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colour, which was also imparted to the spirit, and this having been evaporated, left a fattish, red matter without sensible odour or taste; it is insoluble in either cold or boiling water, but soluble in cold sulphuric æther and alcohol, and does not become turbid by the addition of distilled water, which proves that it is not really fat; neither potash, soda, nor ammonia change the natural colour, nor mineral acids, diluted with water, but when concentrated they destroy, and turn it into a dirty yellow.

The chemical composition of the calcareous covering of the sea-urchins corresponds with the shell of crustaceans, in being made up of a large quantity of carbonate with a little phosphate of lime; and after these have been abstracted by solution in acid, some little thin membranes are left, which may be chitine. The calcareous matter is not deposited in one general mass, as in the lobster's shell, but consists of numerous little angular pieces, which Tiedemann* took the trouble to count in an *echinus saxatilis* of three inches in diameter, and found to be 440, generally of an oblong pentagonal form: these seem to be formed by the carbonate of lime being deposited within the areas, it may be presumed, for it cannot be seen, of an angular arrangement of the outer surface of the hide, which, however, rises up between the adjoining pieces, and connects them in nearly the same manner as the horny plates on the back and breast-plates of the turtle family are connected, and so joins with the thin skin or cuticle with which the shell is overspread.

In the star-fish, of which the tegument is somewhat calcareous, the disposition of the earthy part is reversed; instead of being deposited in the areas, it forms the network itself, the areas being filled by the hide, which is thus more largely covered with the external skin. This calcareous net-work also consists of carbonate of lime, and sometimes, but not always, a little phosphate; thus it is found, according to Hatchett, in *Asterias Papposa*, but not in *Asterias Ruber*. Tiedemann thinks it probable that the earthy matter is secreted by some little glandular structures situated around the mouth of the animal, and emptying themselves into a circular canal, which communicates with a peculiar cavity, always found full of sandy matter, which he calls the *stone canal*, and which is found also in the *Holothuriæ*. If this really be the mode in which the calcareous matter is produced, it presents a curious analogy with the calcareous organs of Poli, the organ of viscosity of Cuvier, by which it is held that the earthy matter is elaborated in the mulluscs.

o. Tegument with earthy deposits.

Between the hide and cuticle or skin of many animals earthy deposits are found of larger or smaller size. Generally where large, they are fewer in number and more massive, as in the tegument of the crocodile, and the button-like masses with sharp projecting spines on their upper surface, as in many of the rays; whilst on the other hand, when small, they are pretty generally spread over the whole surface, as in the granular skin of many sharks and dog-fish, from whence shagreen is manufactured. At other times, though overspreading the entire surface, these granules are collected into patches of an angular shape, as in some of the trunk-fish.

But the most remarkable disposition of earthy matter in the tegument is that forming the armour of the armadillo, and *chlamyphorus truncatus* of Harlan. In the former, the head, upper part and sides of the body and the tail are covered with an earthy shell, consisting of pieces of triangular, square, pentagonal, or hexagonal form, sometimes connected together so as to form transverse, and at other, semicircular bands, but upon the head merely an expanded plate; these little pieces are connected together by delicate processes of the hide passing up between them, and at those parts where they form bands, very distinct folds of skin exist, from whence not unfrequently hairs spring up. The shell of the *chlamyphorus* is described by Harlan* as being "of a consistence somewhat more dense and inflexible than sole leather of equal thickness; it is composed of a series of plates of a square, rhomboidal, or cubical form, each row separated by an epidermal or membranous production reflected above and beneath over the plates." It is by no means improbable that, in all these instances, the substance of which they consist is bone, perhaps with some slight modification of its ordinary mode of formation, but no examination of them has been hitherto made.

OF THE MUCOUS TISSUE.

*Tela Membranæ Mucosæ*, Lat.; *das Gewebe der Schleimhaut*, Germ.; *le Tissu Muqueux*, Fr.

"This system," says Bichat, "to which I attach the name of the fluid, naturally lubrifying it, and furnished by glands inherent to its structure, shows itself throughout in a membranous form, that of bands being entirely foreign to it."† It lines all the cavities of the body, and is connected with the dermal tissue at all the apertures which exist in that structure on the surface of the body, to wit, those of the eyelids, the nostrils, mouth, urinary, and generative organs. By some anatomists it is considered only as part of the cutaneous system, the dermal tissue or common tegument forming the external cutaneous, whilst the mucous tissue forms the internal cutaneous system; "for although," says Meckel, "there is great difference between them, yet are they but modifications of one and the same type, as they are continuous the one with the other without the least interruption, and have fundamentally the same configuration, composition, qualities, and functions."‡ Neither of these statements is, however, correct, for it will be presently shown that all the so called mucous membranes overspread with mucus are not of the same structure; nor is the common tegument continuous without interruption with the mucous membrane, nor of the same composition, nor performing the same function, the similarity between the two extending little beyond their division into an organized or producing, and an inorganized or produced layer.

Employing the term "mucous tissue or mucous membrane," as commonly applied by anatomists to the internal lining of all the canals and cavities connected with the apertures on the surface of the body already

* See his *Anatomie des Röhren-Holothurie des Pomeranzfarbigen Seesterns und Stein-Seeigles*.

* See his *Medical and Physical Researches*, p. 33.
† See Bichat, *loc. cit.* vol. iv. p. 1.
‡ See Meckel, *loc. cit.* vol. i. p. 569.

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mentioned, Bichat divides it into two general mucous membranes, the *gastro-pulmonary* and the *genito-urinary*, of which all the others are portions. The former lines the whole alimentary tube from the mouth to the vent, together with the excretory passages of all the glandular structures opening into it, and at its superior part extends itself upwards into all the nasal cavities, and thence within the eyelids, and downwards throughout the whole interior of the respiratory apparatus. The latter lines the whole extent of the urinary passages even to the tubes of the kidneys, and from the urethra, in the male, is extended into the generative apparatus, whilst in the female, Weber thinks it probable that even the inner membrane of the uterus and Fallopian tubes is to be considered as part of this division. Meckel, as already stated, describing the common tegument and mucous membrane as one system, says "the form of this system is that of a sac inverted upon itself, consequently double, whence are produced both at the upper and lower part of the body apertures, by which the external and internal cutaneous systems communicate, and are continued the one with the other."* He considers the extensions of the internal membrane into the several cavities connected with it merely as so many *culs de sac*, and he does not admit of Bichat's division, contending that "the membrane extending between the orifice of the genital parts and the vent so closely resembles mucous membrane in its softness and the abundance of its secretion, that we are almost compelled to say it unites the two apertures and really confounds them into one." Now, although as regards the human subject and all beasts, except a single order, this is incorrect, as the common tegument is not softer at this than in some other parts of the body, and the secretions, although abundant, are merely sebacine and perspiration, and therefore have not the least resemblance to mucous membrane, yet in the monotrematous order of beasts, in birds, reptiles, and fishes, in which the alimentary, urinary, and generative organs all terminate in one common cavity, Meckel's assertion may be allowed to be correct.

*Anatomical characters.*—Although generally admitted that the so called mucous membrane differs very materially in the different canals which it lines, anatomists have almost entirely rested their description on that part of it which overspreads the interior of the stomach and intestines, though even in these, there must necessarily be difference of character, as the functions they have to perform are widely distinct. It is generally divided into two parts, the secreting or external part, and the secreted or inorganized internal part which overspreads the interior of the alimentary tube, and is in contact with the matter therein contained; these, being analogous to the corion or hide and epidermis or skin of the dermal tissue, have been called by anatomists *mucous corion* and *epidermis* or *epithelium*.

The Mucous Corion is throughout the alimentary canal ensheathed in a tube of musculer fibre, to which it is connected by cellular tissue, often, but very improperly, called *nervous tissue*. The interweaving of the two is as close as that of the under layer of the hide with the subjacent cellular tissue, and therefore they cannot be distinctly separated. This confusion of the mucous and cellular tissue is still further increased by the latter serving as a bed, in which the blood-vessels and nerves ramify prior to their distribution in the former, and these, being torn through in detaching the cellular tissue, produce on the muscular surface of the mucous membrane that flocculent or flaky appearance, by which it is remarkably distinguished from the villous or cut velvet-like pile existing on the free surface, although overspread with its epithelial or cuticular covering. The mucous membrane has a soft but firm texture, and in the human subject is thicker on the stomach than on any other part of the alimentary canal; it is of a rosy red colour on the stomach, but becomes paler and whiter on the small and large intestines, excepting the rectum, where it resumes the reddish appearance. Henle says,* after the removal of its cuticular covering, presently to be spoken of, by washing and squeezing, the mucous membrane consists of threads similar to those of cellular tissue, but of a peculiar softness and granular character, which, to the practised eye, readily distinguish them from the latter, which are also further known by being collected in bundles, whilst the mucous fibres are so complicated that they can scarcely be separated, and from between them, by solution in acetic acid, some dusky granules of small size but varying form, can be obtained.

The inner surface of the mucous membrane is in many parts of the small intestines of man plaited widely so as to form semilunar folds or valves, each equalling about one-third of the circumference of the cavity, and so disposed that either horn of one is received between the horns of other two. These folds are merely for the purpose of increasing the intestinal surface; an analogous, but less extensive, doubling or rather waving of the same membrane, occurs in the large intestines also. In the stomach, when empty, the lining membrane falls into puckers, it being as it were crumpled up by the surrounding muscular coat, but folds, such as exist in the intestine, it has not. This plaiting of the mucous membrane is not a necessary part of its character, for whilst some animals, as the rays, and more especially the sharks and sturgeon, have it disposed so as to form a continuous spiral band, in others it is disposed longitudinally or obliquely, and in some, as carnivorous beasts, no folding of the membrane exists.

The pile-like processes, *villi*, require particular notice, as they are characteristic of the lining, or so called "mucous membrane" of the alimentary canal, and as they have attracted much of the attention of physiologists in reference to their structure and economy. Their form is very various. Helvetius, who first examined them, says that in the human subject they are conical, but in beasts cylindrical. Different animals, however, exhibit them in different forms: thus are they either cylindrical, conical, club-shaped, pointed, triangular, flattened, and of greater or less bulk and length. It appears also, from the observations of Rudolphi and Meckel, that in different parts of the alimentary canal, even of the same animal, they appear under different forms. Lieberkuhn,† who first examined the villi with a microscope, speaks of them as "little conical pendulous membranes overspreading the whole surface of the small intestines, almost touching each other at their base, and scarcely equalling the fifth of a line in size," each of which is furnished with minute arterial branches,

* See Meckel, *loc. cit.* vol. i. p. 569.

* See his *Symbolæ ad Anatomiam Villorum Intestinorum*, p. 18.
† See his *Dissert. Anat. Physiol. de Fabrica et Actione Villorum Intestinorum tenuium Hominis*, p. 25, *et infra*.

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some veins, a nerve, and a branch of a lacteal vessel, which is "expanded into an ampulla or vesicle, not unlike a little egg, upon the tip of which a very minute aperture is detected with the microscope." Into this lacteal vessel, he says that some of the most minute arterial and venous branches terminate with open mouths, so that, after they are filled by injection, it passes into the vesicle, the cavity of which is filled with spongy substance, and thence by the aperture in its tip into the cavity of the intestine. In the interstices of the bases of the villi he observed "a vast number of open mouths of follicles, or rather hollows like honeycomb, in the walls of which, if the vessels of the villi are well injected and the intestine well washed, there are further seen an immense number of vessels, and in the bottoms of the hollows some round and whitish bodies are detected."* These he considered true glandular corpuscules, but observes that "they had no vessels distinct and filled with colour, and that the follicles themselves did not differ much from those which compose the surface of the large intestines, in which, however, he had not then observed these round, cloudy, nebulous corpuscules. The number of these follicles was so great that, in a space containing only eighteen villi, he counted eighty, and of the white corpuscules at their bottom, a hundred and forty-four, that is, eight corpuscules to each villus. These are very curious observations, and in some respects partially correct. Hewson doubts the existence of any ampullar cavity in the villi of the human subject, and having examined them in some other animals, and found them to consist of a net-work of lacteal vessels, he concludes, "since the experiments, from which the villi of the human subject were supposed to contain an ampulla, are so equivocal, and since the villi can be proved in other classes of animals, viz. in birds, fish, and the amphibia, to have net-works of lacteals, as well as of arteries and veins, the probability is in favour of their having the same structure in the human subject." He agrees, however, with Lieberkuhn as regards the orifices, and says, "I have some preparations by me, adapted to the microscope, in Lieberkohn's manner, in which I think I can clearly show the orifices of the lacteals on the extremities of the villi, where there appear sometimes to be one and sometimes to be more orifices."† Cruickshank at first thought he saw these orifices in a bulbous extremity of the lacteal, but repeated examinations led him to alter his opinion, and he says, "in some hundred villi I saw the trunk of a lacteal forming or beginning by radiated branches. The orifices of these radii were very distinct on the surface of the villus, as well as the radii themselves, seen through the (otherwise transparent) external surface passing into the trunk of the lacteal; they were full of a white fluid. There was but one of these trunks in each villus."‡

Opposed to these observations is the assertion of Rudolphi. "I have never found one aperture visible (in the villus); in their interior are nets of blood-vessels, which, however, can rarely be distinguished, except by injection; the net-work of the absorbents also commences in them." Müller's microscopic observations on the villi§ are very interesting: he describes them as "sometimes cylindrical, sometimes leaf-like, often pyramidal short processes of the innermost membrane of the intestine, from a fourth of a line to a whole line, or at the outside to a line and a half in length, and when magnified in water, having the appearance of a thick fur." Such are they in most beasts, in many birds and fishes, and even in some reptiles. Sometimes, as in the ox and sheep, cylindrical and flat villi are found in the same animal, and in the sheep are often seen broad villi with cylindrical tips. Sometimes, when the base of the villus is broad and connected with little folds, it subsides into folds which, in birds and reptiles, correspond to the villi. The extremities of the villi are either round or pointed, and sometimes as it were truncated, and present the same delicate tissue as on their whole surface. Beclard denies that the villi are either conical, cylindrical, canaliform, or enlarged at their tip, as stated by some writers, but says that they appear much rather under the form of leaflets or laminules, and in such number that they present the appearance of an abundant and bushy grass-plot." He describes them as semitransparent, without any aperture on their smooth surface, and without any interior ampulla or vascular texture, "but that in their jelly-like substance there are observed microscopic globules disposed in linear series, and at their base small bundles of sanguineous and lymphatic vessels of extreme delicacy. Müller, however, does not agree with Beclard as regards the internal cavity of the villi, and thinks it an important fact that they are partially hollow within, and are composed of a very delicate membrane, on which blood-vessels ramify. He found a simple cavity, especially in cylindrical villi, and in one instance he discovered in the intestine of a calf, not merely these cavities filled with chyle, but some of them also empty, and which he was able to lay open with a needle. He also satisfied himself that the villi in the ox, sheep, and rabbit were hollow, but in the cat, swine, and dog, that the cavity was less distinct, in the latter indeed the villi seemed hollow only at their upper part. In fishes, as the eel, carp, and shad, he found the little folds not hollow throughout, but closely apposed duplicatures. In the broad flat villi of certain parts of the intestine of the sheep and also of the rabbit, he found more than a single cavity giving origin to the lacteals. As regards the open mouths of the villi, he observes, "although I have never remarked an opening at the extremity of a villus, and although in my earlier examinations I never noticed little minute apertures on the whole surface of the villus, yet have I recently observed in a piece of well washed intestine of the sheep and ox, upon the walls of the villus, and even upon its whole surface indistinctly separated pits, which may be well considered as obliquely penetrating openings." "But whether the villi," he proceeds to say, "have openings or not, it is impossible that they can be the sole organs of absorption, inasmuch as in very many animals they do not exist."* This consideration led him to the microscopic examination of the membrane whence the villi are produced, and which is common to all animals, and he easily found in the intestine of a beast, with the aid of a simple microscope, that the membrane connecting the villi was studded with an immense number of little apertures, from eight to twelve times the size of a beast's blood corpuscule, and frequently so close together that the partitions between them were scarcely as wide as the apertures themselves, but commonly they were farther apart. They certainly

* *Dissert. Anat. &c.* p. 14.

† See his *Experimental Inquiries*, part ii. p. 175.

‡ See his *Anatomy of the Absorbing Vessels*, p. 59.

§ See his *Physiologie*, p. 252, *et seq.*

* See Cruickshank, p. 254.

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 were not mere pits but veritable little apertures, of which any one may be satisfied if he endeavour to remove the delicate membrane in a rabbit." He says also that he found them in all the animals he examined, sometimes more, at other times less distinct, to wit in beasts, reptiles, and fishes, though in the latter two classes with greater difficulty, as they are more widely separated. In the sheep and ox he "saw also the broad base of the villus as it were pierced, and the distinct depressions on its walls gradually run into the pits already mentioned, as being probably obliquely perforating apertures." From this account there can be little doubt that these apertures are the mouths of the follicles described by Lieberkuhn, in the bottom of which round whitish bodies are seen. Müller, however, states that "it is impossible to distinguish with certainty these openings from the mucous follicles, and to determine positively as to their being the actual commencement of the lymphatic vascular net of the intestine"—although in the very next sentence he says, "but where there are large masses of mucous glands, the mucous glands and their apertures can be accurately distinguished. In certain parts of the small intestine of the ox, the mucous follicles are as close together as flour sacks, immediately behind the thin perforated membrane;" this, he soon after says, sends little processes between the follicles, which are connected beyond these to a delicate membrane within the muscular coat of the intestine. In these compartments the mucous follicles have their large basal end attached to the thin membrane, whilst their aperture has a neck so thin that, in the space between four of them, twenty apertures in the perforated membrane may be counted, and each mucous orifice corresponds to a flat depression in this membrane, in the centre of which it opens, surrounded by numerous very small apertures, the interspaces, however, between the pits being also minutely perforated.

From this account it would seem that the villosities of the mucous membrane in the intestines are analogous to the papillæ of the hide, for whilst in the latter the minute branches of the nerves are expanded so as to collect, by the sense of touch, our relations with external objects, so in the former the minute branches of the absorbing vessels are outspread to facilitate their function of abstracting the nutritious part of the food, either by open mouths or through their membranous covering, and hence are, as Beclard calls them, "animal radicles." Another analogy exists between the hide and the so called mucous membrane, in both being overspread with a peculiar secretion suitable to resist the action of irritants to which they are constantly exposed, and to preserve them in a proper condition to allow the performance of the functions of those organs which they invest and protect: thus in the hide are implanted sebaceous glands for the secretion of the oily sebacine, and in the mucous membrane similar structures by which glary mucus is produced.

The apparatus by which the intestinal canal is furnished with mucus, consists of three sets of glands, viz., the follicles of Lieberkuhn, the follicles of Brunner, and the glands of Peyer. The former of these have been already described, are spread over the whole surface of the small intestine, and when sufficiently magnified give it, as Müller says, "the appearance of a sieve." The second are found only in the duodenum, and do not extend beyond the commencement of the jejunum; they are little solid glands, made up of minute lobules which are embedded in the cellular tissue connecting the mucous and muscular coat of the intestines; they exist in great numbers near the pylorus, and form, according to Boehm, a continuous layer in the coats of the intestines. The third set, the Peyerian glands, are situated in that part of the intestine opposite the attachment of the mesentery. Rudolphi, only in the most general terms, describes the various forms of these mostly oval, thick portions of the mucous membrane. Boehm* and Müller have both examined and described these structures. The latter says that the greater thickness of the membrane at these patches partially depends on the size of the villi, which are here generally broader, and especially at their base, and partially on the tissue of the mucous membrane itself. The Lieberkuhnian glands are very numerous between the villi, and between them are observed larger circumscribed white patches of the mucous membrane about a line broad, which in man are flat, and but little raised; in the dog, cat, and rabbit, are pretty prominent, and in the dog resemble white papillæ; in other instances they have a great similarity to the *papillæ vallatæ* of the tongue, being in the cat and rabbit bounded by a circular groove and having a flattened surface. These round white spots are in all cases surrounded by a ring of apertures, about ten or more in number, which appear as little apertures between the villi like Lieberkuhn's follicles, but distinguished from them by being sometimes rather oblong than round, so that their long diameter is in the direction of the radius of the white spot. Upon those which are papillar in brutes no apertures are seen except in birds, where a single opening is found. Müller also observed in the cat that the ring is surrounded by a very delicate sheath-like fold. These white patches are generally devoid of villi, but occasionally traces of short villi occur, and sometimes even a very short, white pyramid, pointing to the smooth surface. No attempt to express any secretion from them or to prove their follicular structure, nor to express any thing from the encircling apertures, has succeeded. If, however, the surface be removed, a cavity is found corresponding to the white surface, and rather shallower than its breadth, and containing a greyish-white mucous-like matter, inclosed in the very thin covering of the part. The granules in this matter are blood corpuscules and smaller than mucous granules. Thus open follicles or cells the Peyerian glands have not, and what the sacs are is unknown.

The mucous membrane of the upper part of the alimentary canal from the mouth to the termination of the gullet in the stomach, and in many instances of a considerable part of the latter organ, is remarkably distinguished from that of the intestinal canal in being entirely devoid of the villi, which form the distinctive character of the intestine in the higher classes of animals. It also so closely resembles the external tegument of the body, except in being largely besmeared with mucus, that by many writers it has been held to be merely a continuation of the dermal tissue, and this opinion has been supported by the fact of variolous pustules being occasionally found in the mouth, throat, and œsophagus as well as in the air-passages, but never in the villous membrane of the intestines. To this also may be added that in many animals the membrane is, at least in the mouth, overspread with dark pigment. The mucous

* See his Essay *De Glandul. Intest. Structura penitiori.*

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membrane of the mouth is very thin and delicate, and is generally of a reddish colour in all vertebrate animals, except fishes; in the gullet, however, it becomes paler, and is generally disposed into folds, which allow the distension of that canal often to a considerable size for the passage of the food into the stomach. In the chelonian reptiles and serpents, Purkinje and Valentin have discovered ciliary organs in the mucous membrane of the mouth, throat, and gullet, as far as the commencement of the stomach, but not beyond. The mouth is largely furnished with follicles for the secretion of mucus, consisting of little hollow cylinders with narrow orifices, similar to the sebaceous follicles of the external tegument, which are generally distinct, and from their situation within the lips and cheeks are often called *labial* and *buccal glands* or *follicles*. Between the arches of the throat they are of much larger size, and being collected into bundles form the *tonsil glands*. Mucous follicles are likewise largely distributed in the lining membrane of the pharynx and gullet, and also about the termination of the latter in the stomach, to which the title of *cardiac glands* has been assigned.

From the mucous membrane of the mouth are sent processes which line all the air-passages and cavities connected with them, as the wind-pipe and its extreme branches, the cavities of the nostrils, and those of the frontal, ethmoid, sphenoid, and maxillary bones. With all these parts the membrane is very closely connected, and when lining bony cavities serves at the same time as a periosteal covering. In the wind-pipe and nostrils the mucus is secreted in follicles as in the mouth; but in the other cavities just mentioned no follicles are found, hence Müller justly observes that "the follicles therefore cannot be considered as the sole organs of mucous secretion."* Ciliary motions have been also discovered by Purkinje and Valentin on the mucous membranes of all these organs in all the vertebrate classes; but they have not been discovered either on the conjunctive coat of the eye, nor on the lining of the lachrymal passages. The interior of the stomach exhibits very different characters in the different orders of animals; sometimes it is covered to a very slight distance by an extension of the mucous membrane of the gullet, as in the swine; in others, as the horse, this membrane overspreads nearly the entire half nearest the gullet; in these cases it is disposed in irregular folds. But when, as occasionally happens, the stomach is divided into distinct cavities, as in ruminant animals, it assumes a reticular or honeycomb appearance, or throws out numerous round or pointed papillæ, often of considerable size. The honeycomb disposition which occurs in the second stomach, both of ruminant animals and of the porpoise, has been examined by Dr. Brewster in the latter animal, and the following is his account: "It seems, in its wet state, to consist of tubes or fibres, perpendicular to the two membranes which enclose them, and the upper surface of one of the membranes is covered with hollows or depressions corresponding with the extremities of the tubes or fibres. A more minute examination, conducted in a different way, proved these perpendicular portions to be tubes. In order to dry it, I pressed it between folds of paper, and the effect of the compression was to press together nearly all the tubes and make the whole one dense mass, of a dark brown colour; but when it became dry and slightly indurated, I drew it out as if it had been Indian rubber, and the tubes opened and the mass became white."*

* See Meckel, *loc. cit.* p. 415.

The stomach, however, has sometimes part and sometimes the whole of its internal surface covered with a membrane highly vascular, and having the same apparent villous character as that of the intestinal canal. These villi cannot, however, be considered the same structures as those of the intestine, for they certainly are not produced by the intrusion of the radicles of absorbents, neither do they take up chyle. Their structure has not yet been satisfactorily stated, or rather they are spoken of indiscriminately as secreting two very distinct matters, mucus and gastric juice, a double function which it is highly improbable that they perform.

Dr. Sprott Boyd† has, within the last few years, examined the lining membrane of the stomach, and describes it as having, in parts, a velvet-like appearance depending on the existence of minute folds, but throughout it presents small hexagonal cells from $\frac{1}{250}$ to $\frac{1}{120}$ of an inch in diameter, and near the pylorus as much as $\frac{1}{100}$ of an inch. In the bottom of these cells were numerous minute openings; and when a vertical section was made, perpendicular fibres were seen, which he presumed were tubes opening into the cells, as in the pig he could perceive they were hollow. This account corresponds very closely with that of the second stomach of the porpoise, given by Dr. Brewster, and it will be highly interesting if verified; as it would seem probable that this apparatus is for the secretion of the gastric juice and not for that of mucus. Mucous glands the stomach certainly has, viz., the Brunnerian glands, which are distributed almost entirely along the curvatures of the organ.

It was formerly taught that the mucous membrane lining the alimentary canal and air-passages is overspread with a thin horny layer, which was called the *epithelium*, and considered to be merely a very delicate sort of cuticle or skin. Its existence was proved by scalding the mouth and gullet, from either of which it then readily peeled off in flakes of thin pellicle, but it could not be so separated in the intestine. That cuticle does exist, however, in the stomachs of many beasts, as in part of the stomach of the swine and horse, and still more decidedly in some of the entire cavities into which the stomach is divided in ruminant animals, and in the porpoise; and again also, as a very thick horny lining in the gizzards of granivorous birds, has been long since known. But it has been of late held by anatomists that it cannot be traced in the human subject beyond the termination of the gullet. If, however, the observations of Henle be correct, the lining membrane of the mouth and gullet are covered with a horny layer, closely resembling skin, and though this decidedly ceases at the lower end of the latter, yet it speedily reappears in the stomach with some modification, and subsequently even in the intestine, although there exhibiting some remarkably distinct characters. These points, it has been Henle's object to prove, and with that intention he has commenced by adverting to the opinion first broached by Leeuwenhoek, that the external skin of the body consists of layers of scales, which from his own examination "present generally the appearance of cells with straight edges,

* See *Edinburgh Philosophical Journal.*

† See his Inaugural Dissertation *On the Structure of the Mucous Membrane of the Stomach.*



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mostly disposed in quincunxes, and all provided with a nucleus."* He then proceeds to examine the covering of the mucous membrane, and finds that this epithelium which lines the interior of the mouth, and thence extends within the œsophagus down to the cardiac extremity of the stomach, consists also of scales sometimes marked with parallel straight streaks, and having flat, oblong, and granulated nuclei; and that, as they approach the stomach, the scales disappear, so that at the lower part of the gullet there remain only the cells in which the scales seem to be formed, and which higher up had been deposited in the deepest part of the epithelium. In the stomach itself the nucleated scales are again seen, but in a thinner layer and deciduous, and near the pylorus both scales and cells entirely disappear. To this cellular and subsequently laminar arrangement of the horny covering, he restricts the term *epithelium*, and it bears a striking analogy to the external skin.† Very different, however, from either skin or epithelium is the covering of the intestinal mucous membrane, which he thus describes: "A very delicate layer of cylinders, devoid of colour, overspread the whole internal face of the intestine, but colourless, and containing always a nucleus of very regular and decided form, nearly in the centre of the cylinder, and of similar size and form to those of the skin and epithelium. In the centre of each nucleus the very small dusky granules simulate the appearance of a second nucleus; more frequently also the inner circle next the edge resembles a circle of distant lines. The other substance of the cylinder, much lighter then the nucleus, is almost pellucid. The apex, turned towards the mucous tunic, is gradually constringed, but the edge of the other thicker and exposed extremity is straight or slightly convex; sometimes it may be obliquely truncated, and always darker than the other part. Its sides either converge backwards in a straight line, or swell out a little opposite the nucleus."‡ These cylinders, he presumes, are connected by homogeneous glutinous matter, which sometimes rises above and gives them a regular and thin covering. From like cylinders which are found in the gall-bladder, this layer may in the rabbit be removed; its external surface is smooth, but the inner consists of folds which form cells, and of distinct, sharp, horny points, both of which may be considered as moulds of the spaces intervening between the cylinders. The union of a few of these cylinders form only globules of a nearly cubical shape, but when many are collected together, whitish delicate membranes are produced, of two kinds, 1. those between the villi, which seem cribrous where two or three cylinders have dropped out, but elsewhere form a reticular layer; and 2. those which invest the villi themselves, and assume their form, but are not cribrous. This membrane or *cuticle*, as Henle calls it, be found in all the intestines of man and brute dissolved in or rather into the intestinel mucus, and also in animals recently killed, adherent and perfect on the mucous membrane. It separates like skin and epithelium by putrefaction after death as well as during life, and in young animals especially large quantities of its particles are found, but even in adults it certainly falls off and is reproduced, as the slightest touch removes it from the mucous membrane, end as n very great number of cylinders are seen in the excrescent. He finds also that these *mucous cylinders* dissolved in water, but after daily maceration, are gradually converted into a granuler matter of indefinite form; that they are not acted on by æther or alcohol; that efter maceration for eight days in caustic or carbonate of ammonia they are unaltered; that in caustic or carbonate of potass they gradually become pale, and after a short time cannot be recognized; that in acetic acid they suddenly fede, are then dissolved, the nuclei at first remeining, but even they, after some hours, cease to be visible; that the acid contained in the stomach dissolves them, whence he accounts for finding sometimes in the duodenum only the nuclei of cylinders; but that neither nitric, sulphuric nor muriatic acid, dilute or concentrated, in any way effects them. Hence he concludes that the intestines have no true squamous epithelium, but are only overspread with these mucous cylinders, which, by repeated washing and squeezing, can be completely removed, and leave then only the mucous membrene with its papillæ and Lieberkuhnian fossules or follicles.

Mucous membranes are amongst the most vascular parts of the body. If a portion of intestine be well injected, the vessels are so oumerous and so close, that their ramifications cannot be observed, nor any space between them. Weber measured their size in some of the preparations at the Berlin Museum, and found on the mucous membrane of the large intestines, of the intestinal villi, of the stomach, nose, and conjunctive coat, that they were only $\frac{1}{1000}$ to $\frac{1}{2000}$ of an inch in diameter, and therefore from six to ten times smaller than a hair of the head. Upon the villi no interspaces could be seen; on the large intestine they were lengthy, angular, and irregular, and their shortest diameter about equal to that of the vessel.* According to Prochaska, all mucous membranes are not equally vascular: thus that lining the nostrils is rendered very red by injection, but that of the frontal, sphenoidal, and maxillary cavities much less so; and again, that part of the conjunctiva lining the eyelids is as red as the membrane of the mouth, whilst that which spreads upon the eye-ball is very moderately red. The villi of the intestines when injected, become erect, and even in the living animal, if the portal vein be tied, the same occurrence takes place by the return of the blood being stopped. Weber mentions an experiment of this kind on a dog, which lived for an hour and a half after the operation; the lining membrane of the duodenum was a line thick, its villi also of similar length, and their free rounded extremity swollen nearly to the size of a millet seed.

Besides lining those internal passages of the body which have external openings, mucous tissue is found disposed in form of sacs or follicles, similar to those in the mouth, upon the outer surface of the body, in some entire classes of animals, as fishes, molluscs, annelids, &c., and part of the class of reptiles, which are consequently largely overspread with mucus. This affords another argument in support of Meckel's opinion that the dermal and mucous tissue ere only parts of the same system, modified according to the position in which they are placed end the office they have to perform in the generel œconomy of the body. In fishes especielly is this modification very strongly marked, the mucous follicles being ranged on each side of the body which runs from the gill opening to the tail, forming the lateral

* See Henle, *loc. cit.* p. 4.
† See *Ib.* p. 10.
‡ See *Ib.* p. 14.

* See Weber, *loc. cit.* p. 442.

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line, usually distinguishable by the delicate holes in the series of scales which cover them, and which not unfrequently have a distinct colour from the other parts of the body. As almost all the animals whose external surface is thus lubricated with mucus have their habitation for the most part, or entirely, in water, either fresh or salt, it is natural to suppose that its use is to defend their skin from the action of the moisture, in precisely the same way as the sebacine protects the skin of those animals which live in air from its effects.

*Chemical characters.* Mucous membrane, when exposed to air, soon putrefies, assumes a greyish colour, and readily separates from the subjacent cellular tissue, which undergoes that process much more slowly. Bichat says,* that when macerated it is decomposed by water, only less quickly than the substance of the brain, and is then reduced to a reddish pulp. After having boiled for some time it loses its whiteness, and becomes of a deep grey; it does not become softer, nor does it ever assume the gelatinous appearance of the dermal tissue, fibrous, or cartilaginous tissue after boiling. Bichat, however, admits that he has obtained a distinct precipitate by the addition of tannin to water in which mucous membrane had been boiled. It is more readily acted on by acids than the dermal tissue, even during life.

Of *Mucus.*—The surface of all mucous membranes is protected by their peculiar secretion, called mucus, which forms a thinner or thicker coating to them, preserves their softness, and lubricates them. It is a thickish fluid, viscous, capable of being drawn into threads, clear as water, or opaque and whitish. It contains numerous soft, flattened, rounded granules, from $\frac{1}{300}$ to $\frac{1}{400}$ of an inch in diameter, which, by friction, can be divided into smaller round granules from $\frac{1}{300}$ to $\frac{1}{1000}$ of an inch in diameter. It swells in water, but is not dissolved by it, though it may be diffused in it, and can then be precipitated by alcohol. Mucus is nearly allied to uncoagulated white of egg or albumen, and, according to Tiedemann and Gmelin, is only a modification of albumen; but it is distinguished from it by not coagulating in a heat of 60° to 80° of Fahrenheit's scale. It is distinguished from gelatine by its minute division in water, by its non-conversion into jelly, and by its very slight solution in cold or warm water; and in acids it is less soluble than albumen, fibrous matter, or gelatine. According to Krause, the mucus of the small intestines consists especially of water and mucosine, or true mucus, with a very small quantity of soda; it also contains a very small quantity of alcoholic extracts with lactic salts, and of watery extracts with phosphoric salts, also of chlorate of potass and soda. Although the mucus has generally pretty nearly the same character, yet, as Berzelius has justly observed, it has different peculiarities in the nostrils, air-tube, gall-bladder, urinary bladder, and intestines, without which it could not fulfil the object intended. According to this chemist, the mucus of the nose is soluble in weak sulphuric and nitric acid, but not in acetic acid even at the boiling heat, which then indeed hardens it; he found also that the latter acid precipitated without dissolving the mucus of the gall-bladder; whilst that of the urinary bladder is partially soluble in both dilute acids and alkalies. Tiedemann and Gmelin state that the mucus of the intestines of a dog is but slightly soluble in dilute, and specially cold sulphuric, muriatic, nitric, or acetous acid; that the mucus of the gall-bladder is completely insoluble in dilute nitric acid, and that even after many days' mixture with sulphuric and muriatic acid it is very slightly soluble. By many it has been supposed that mucus is contained in the blood, and in the fluids of the close cavities of the body; this, however, is denied by Berzelius, who says that osmazome, connected with lactic salts, has, on account of its mucous appearance and indisposition to coagulate, been incorrectly supposed to be mucus, although mucus itself is insoluble in spirits of wine.

* See Bichat, *loc. cit.* vol. iv. p. 433.



### Of the Dental Tissue.

*Tela Dentium*, Lat.; *das Zahngewebe*, Germ.

Weber has improperly placed teeth as well as horn among his Simple Tissues, for a very slight examination shows their complicated structure; and their close approximation to Osseous Tissue is proved by microscopic examination. As to the place which the dental tissue should hold, there can be little doubt it should follow mucous tissue, as, from the discoveries of Arnold and Goodsir, in all cases the teeth are formed on bulbs derived from that tissue, which subsequently, as they are developed, are covered or converted into the gristly, horny, or bone-like substances which are called teeth. Although in man, and the other vertebrate classes, excepting birds, the teeth are mostly hard and firm textures, yet even among them are some containing little or no earthy matter upon which their solidity depends, but only consisting of a structure very like hoof, already described as made up of horny tubes like matted hairs, thus indicating their relations to those modifications of the dermal tissue, by which hair and hoof are produced. This connection between teeth in general, as a product of the mucous tissue and hairs, as evolved from dermal tissue, is further supported by the modern discoveries of the tubular structure of the hardest teeth, or such as contain the largest quantity of earth of any animal product. The difference in substance and texture of the teeth had led Illiger to divide them into two kinds, *Elasmia*, or horny plates, of which the threads composing them split up, and as it were form long fringes, as in the teeth of the whalebone whale; and *Dentes* or true teeth, in which less or greater quantity of earthy matter is deposited to give them solidity and strength, and enable them to perform the office of "holders or retainers, which may be called killers; dividers, crackers, and grinders," as Mr. Hunter rather quaintly observes. As, however, all are formed on the same model, and the difference is in fact only as to the existence of the earthy component, it will be sufficient here to consider more particularly those which are tough and hard in proportion to the quantity of lime they contain.

All teeth are formed upon pulps, which, after a certain evolution, are converted into a peculiar animal substance, very similar to, if not indeed, cartilage, in which earthy matter is deposited. Sometimes a tooth has but one of these pulps, and is then called a *simple* tooth, as those of man and many animals; at other times two, three, or more pulps enter into the composition of one tooth, and such are called *compound* teeth, as in the grinding teeth of the elephant, ruminating animals, &c. The pulps of the compound teeth are generally persistent, that is, continue in being, and by the addition of new matter to the bottom of the tooth supply the wear which is constantly



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occurring on the top or crown. Among simple teeth also, as in the front chisel-like teeth, the pulp is persistent, and the tooth continues to grow through life. But in most simple teeth, their formation is perfected at a certain period, and the pulp ceases to exist as a distinct substance, and leaves, as its only representative, the vessels which are found in the cavity of the tooth.

The hard part of a tooth generally consists of three substances, tooth-substance or dentine, enamel or adamantine or vitreous substance, and cement or petrous, or cortical substance; but the three are occasionally not present together, and upon this circumstance materially depends the difference of the teeth in different classes of animals. Of the true structure of these several parts little was known till within the last few years; the few, though correct, observations of Leeuwenhoek having been entirely forgotten, and only again brought to light since the recent discoveries of Purkinje and Retzius; and it is an interesting circumstance that both these able inquirers should have been simultaneously, though unconsciously, engaged in the pursuit of the same subject, and that the result of their inquiries should so nearly correspond. The discoveries of Purkinje were published in October, 1835, in the inaugural treatise of Fraenkel, *De penitiori Dentium humanorum Structura Observationes*, and also in that of Raschkow, entitled *Meletemata circa Mammalium Dentium Evolutionem*. The parallel observations of Retzius were communicated to his friends Berzelius, Urede, and Wahlberg, at the close of the same year, and his paper, *Mikroskopiska Undersökningar öfver Jüdernes särdeles Tandbenets strucktur*, laid before the Academy of Sciences at Stockholm, on January 13, 1836. Subsequently to which he wrote another paper, communicating further discoveries to his friend, Dr. Creplin, a translation of which is given in Müller's *Archiv für Anatomie, Physiologie, &c.*, 1837, with the title *Bemerkungen über den innern Bau der Zähne, mit besonderer Rücksicht auf den im Zahnknochen vorkommenden Röhrenbau.* In this paper, after stating that he was led by the perusal of Brewster's admirable description of the chrystalline lenze,* to think that the pearly appearance of tooth-bone was an indication of the regular existence of close set fibres, on which the refraction of the rays of light might produce the same phenomenon, he gives a very general account of his discovery of the wavy close set fibres, composing tooth-cartilage, of their tubular character, and of their ramifications; also of the composition of enamel, and the existence of cement, or cortical substance, on the human teeth, and also on those of several other animals. These observations, he says, he communicated to the Academy without being at the time aware that any one had held the same views; but soon after he discovered that Leeuwenhoek, in his *Microscopical Observations on the Teeth and other Bones, Philos. Trans.*, 1678, had taught that the human teeth consisted of hollow tubes, and that he himself had also found the same tubes in the elephant, cow, and haddock; and subsequently he found in the *Continuatio Epistolarum*, vol. iii. p. 1, of the same distinguished philosopher, that he had examined the teeth of horses and swine, and ascertained that they were made up of nothing else than tubes passing from the cavity to the periphery of the tooth; and a little further on, that he was aware of the existence of the cortical substance in the calf, "*adeo ut jam me adhuc magis quam antea certum reddere possem, circum primo confectum dentem os accrevisse.*" Retzius generously allows Purkinje's right to the priority of discovery of the formation and intimate structure of the enamel, and also of his re-discovery of the tubes in the tooth-bone, observing that "with perfect justice it is to be considered as a new discovery, since Leeuwenhoek's discovery had remained unnoticed and useless for more than a century and a half."*

### *Of Tooth-Substance.*

The tooth-substance is the essential part of a perfect tooth, upon which depends its form and connection with the general system. It is the *Bone of the Tooth* of Hunter, the *Osseous substance of the Tooth* of Cuvier, the *Proper Tooth-substance* of Purkinje and Fraenkel, the *Tooth-bone* of Retzius, and *Dentine* of Owen; but the latter designation has been objected to, as its terminal, according to present usage, would indicate it as a primary element, which it is not. The expression *ivory* is also not unfrequently applied to this structure, but as this term is generally employed to denote one particular kind which has peculiar characters, it is scarcely suitable as a general name. The structure of tooth-substance was hinted at by Malpighi, who describes it as "the interior bony lamella (of a tooth), consisting of fibrous and as it were tendinous capillaments interwoven." These Leeuwenhoek subsequently and correctly proved, both in human and swine's teeth, to be not fibres, but "tuboles spreading from the central cavity to the circumference" of a tooth. His observations, however, were forgotten or overlooked, and even Mr. Hunter, in his *Natural History of the Human Teeth*, speaks of this substance as "bony," with the addition, however, "but much harder than the most compact part of bones in general;" whilst Fred. Cuvier calls it "an ivory of silky appearance formed of fibres." The recent observations of Purkinje and Retzius have, however, proved the truth of Leeuwenhoek's statement of its tubular character beyond all doubt, and show that the tubes are embedded in an interstitial substance. Purkinje and Fraenkel commence† their description by stating that "the structure of the proper dental substance is entirely fibrous;" subsequently that "the extremely narrow space between the several fibres is filled up with a substance exhibiting no determinate structure, which may therefore be considered as the fundamental part of the dental substance;" and afterwards, that the just mentioned fibres "appear to be round and hollowed, so that they may properly be called *tubes*." In transverse sections of the crown of a tooth examined with a low magnifying power, they noticed the divided tubes like points of equal density and frequency, with distinct boundaries, but pellucid in their middle. When, however, a higher power was employed, instead of spots, well defined and distinct circles became apparent, separate from each other, and of which the interior, illuminated by a stronger light, plainly exhibited a sort of mouth; whilst the circles themselves were surrounded with the very simple tissue forming the fundamental part of the tooth-substance, so that each presented as it were two circles, the first

* *On the Anatomical and Optical Structure of the Chrystalline Lenses of Animals*, in *Phil. Trans.*, 1833, p. 332, 1838, p. 35.

* See Meckel, *Archiv*, 1837, p. 490.

† See Fraenkel, *Dissert.* p. 10, *et infra.*

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Zoology. formed by the walls of the tube itself, and the second by the fundamental substance. Further proof of the tubularity of the fibres was also obtained by making sections parallel to the axis of the tooth, and sufficiently thin to divide each fibre longitudinally, by which their canals were distinctly laid open throughout their whole length. Müller, in his very scanty observations* on the subject, at once describes "the proper tooth-substance as consisting of an homogeneous, structureless part, and fibres penetrating through it." He confirms Purkinje's statement of their tubular character, and that, at least in the tooth of a horse, they in part, by their capillarity, absorb ink. The tubes (*dentinal tubes* of Owen) pass from the circumference to the central hollow or pulp-cavity of the tooth, for the most part perpendicularly to the surface, but, in reference to the whole tooth, they vary in direction according to their situation: thus on the crown they are vertical, whilst on the sides they are more or less oblique and horizontal, so that they appear as rays converging to a centre, which centre is the pulp-cavity. In their course they assume a wavy direction, consisting of numerous curves which, according to Retzius,† take the form of the Greek letter ζ, but they often deviate so as to accommodate each other and avoid intersection. The same writer observes that the curves are very various; that sometimes they are fourfold, sometimes only double, like the letter S; at other times merely single, and occasionally that the tube passes straight from the surface to the pulp-cavity, as on the middle of the crown of the tooth. Besides these larger curves, he also describes other short, close-following curves in the tubes, of which he has counted two hundred within the extent of a Paris inch; these also vary in different teeth. The curves in well formed teeth correspond on both sides, hence the pulp-cavity is symmetrical. As the neighbouring tubes seem to be parallel, although they are actually disposed in a radiated form, Leeuwenhoek endeavoured to ascertain how it was that the space occupied by them near the pulp-cavity was less than that towards the surface of the tooth, but he sought in vain for any trace of ramification. The branchings of the tubes did not, however, escape the observation of Purkinje and Fraenkel, who say on this point, "*fibras invenêramus quæ ramulos ad circumjacentes porrigerent, nunquam tamen deteximus quæ sese ecarent.*"‡ Retzius has fully described them, and according to his observations, although, in old human teeth, the tubes appear as if they neither divided nor gave off branches, and even under the microscope seem of equal size throughout the greater part of their extent, yet such, however, is not really the case, for they do divide, do give off branches, and their calibre is, without exception, diminished towards their outer end. From the openings of the tubes into the pulp-cavity, the sides of which, from their great number, resemble a sieve, to the middle of their outermost third, they seem to be of equal size, about $\frac{1}{717}$ of a Paris line; but from this point their diameter is distinctly lessened, and they either vanish or terminate in little irregular, round, and scattered cells. In the middle of their course they are distant from each other about three diameters, but much closer near the pulp-cavity according to Retzius.§ Müller, however, says they are five or six diameters distant. The principal tubes in part divide dichotomously, in part give off throughout their whole extent an immense number of branches which again divide, and are principally distributed in the otherwise void spaces between the adjoining trunks, the remainder pass over those trunks, and seem to meander in the neighbouring voids. In the permanent teeth of the human subject Retzius says that the ramifications are, almost without exception, at the outer extremities of the tubes, whilst those arising nearer the pulp-cavity are much fewer, and often appear merely as little irregularities or points on the principal tubes. And he adds, with reference to these ramifications and cells, "I have not been able to find that the branches which arise from different tubes are connected with each other, if not, perhaps, at their outermost extremities,"* and "the cells are the smallest, and with the greatest difficulty discoverable."† In most beasts the branchings of the tubes are readily seen dividing freely towards the surface of the tooth, some terminating in cells, and some anastomosing with each other. Retzius has described them in several beasts, reptiles, and fishes, and the subject has been still further pursued and illustrated by Owen, in the beautiful microscopic illustrations of his *Odontography*. According to the proximity of the tubes is the density of the tooth-substance, and it is upon this circumstance that *ivory* is distinguished, although only a more dense kind of tooth-substance. According to Retzius, the tubes in the elephant's tusk are throughout their whole extent much smaller than in the human subject, their medium diameter being $\frac{1}{1150}$ of a Paris line, and their distance from each other scarcely so much. Their waviness is hardly distinguishable, but, on the other hand, they make an immense number of parallel, almost angular bends, of which one follows another, sometimes at a distance of $\frac{1}{28}$ of a Paris line, and sometimes still farther apart. They stretch out as it seems in two planes, intersecting each other at right angles; and between their parallel bends are numerous cells which, on a transverse section of the tusk, present the appearance of regular, beautiful rings around its pulp-cavity or axis, of which some are about $\frac{1}{78}$ of a Paris inch apart, and some are so delicate as to be invisible to the naked eye. The tubes themselves in their course divide, as those in most other teeth, more and more as they approach the outer surface, at very acute angles, and they also give off some short, very close following branches, which together fill up the gradually increasing interspaces produced by the divergence of the tubes from their centre.‡ From Purkinje and Fraenkel's paper it does not appear whether they were aware of the contents of the tubes of the tooth-substance. Müller, however, took up the subject and says,§ that "after repeated observations he concludes they are filled, at least partially, with inorganic deposits (salts of lime) soluble in acids. In thin sections of tooth, viewed with a strong light, it can be easily seen that the white colour of the tooth depends merely on these fibres or tubes, and that the interstitial substance is more transparent. But if such section be treated with acid it loses the white colour of its fibres.

* See his *Jahresbericht*, 1835, in *Archiv für Anatomie, &c.* 1836, p. 2.
† See his Letter in Müller's *Archiv*, 1837, p. 491, *et infra*.
‡ See Fraenkel, *loc. cit.* p. 11.
§ See Retzius, *loc. cit.* p. 494.

* Retzius, p. 495.
† *Ib.* p. 558.
‡ *Ib.* p. 509.
§ See Müller, *loc. cit.* p. 2.

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and the remaining tooth-cartilage still presents the tubes within it, but when dried they are no longer white." In support of his assertion he brings forward the observations of Lindsrer on the loss of colour of dentine in caries of the teeth, and says that with the aid of a microscope he himself also ascertained the existence of some crumbling matter soluble in acid. "But," he continues, "I have very often made the same observation on very fine slices of healthy tooth, in which there are several, frequently many, fibres containing dusky spots closely following each other. As the tooth fibres lose their white colour by acid, whilst the intervening tooth-substance remains transparent, so must either the walls of the tubes or their interior contain lime-salt. In fracture of a delicate section of a tooth in the vertical direction of the fibres, I have often seen on the edge a little fragment standing up stiffly from the tooth-substance; in this case it stood upright and uncurved, and it appeared to be particularly inflexible. When, on the contrary, the calcareous earth had been abstracted by acid, and the remaining cartilaginous plate was torn contrary to the fibres, they appeared on the edge of the rent, often projecting far, and quite flexible and transparent. Hence the tubes must have an animal base, membrane, which in solid teeth being stiff and frangible, must be probably penetrated by lime salts, but is soft in those teeth which have lost their lime."* The calcareous salt is contained not merely in the tubes, but also in the interstitial substance of the tubes, and the greater part of it in the interstitial substance, either chemically connected with the cartilage or deposited in it in some unknown way. The lime of the interstitial substance may be made apparent by boiling thin layers of tooth in potash-lees for a few hours; the previously transparent interstitial substance of the fibres is then rendered opaque and white, whilst the cartilage is for the most part dissolved. The plates are then extremely frangible and can only with the greatest care be more ground. The lime appears in close-set granules, and in some teeth thus treated, streaks are observed parallel to the pulp-cavity. These tubes, shown by Müller, and also by Retzius, to contain salts of lime, have recently been named by Owen calcigerous tubes, and are connected with the lime-cells discovered by Retzius.

The *Calcigerous* or *Lime Cells*, existing in human tooth-substance, are very briefly noticed by Retzius as being the smallest and most difficult to discover. He gives, however, a description of them in many animals, and states that they fill up the interspaces between the ramifications of the calcigerous tubes which, in part, terminate in them by very minute branches, and in part anastomose with each other. The cells in the lynx are of an oblong shape, have the lime tubes disposed around them in whirls, and are arranged in scattered rows; in the shrew, the extreme branches of the tubes terminate in sharp pointed cones, which give origin to other branches of similar size; in the sheep, two rows of these cells exist, one in the middle-third of the tooth-substance, consisting of oval nodules, the largest of which are $\frac{1}{75}$ of a Paris line broad, and $\frac{1}{50}$ long, on the inner side of which branches are received from the tubes; the other row, which are of a scale-like form, occupy the outer edge of the dentine, and are received at the minute terminations of the branches of the tubes; in the horse, the cells are angular, and very numerous on the outer surface of the tooth, immediately beneath the enamel; the delicate branches of the tubes terminate partially in these cells, and partially by anastomosing with each other, in addition to which the cells also send off branches to connect themselves with each other, and thus an extensive anastomosing net-work is formed. In the elephant, some of the cells are of an angular shape, and scattered about like sand, but others are of larger size, heaped up, and connected together.

In the preceding description of the tubular structure of the tooth-bone given by Retzius, only one kind of tubes are mentioned, which divide into very minute branches, and terminate on the surface of the tooth, either by mutual anastomosis or by opening into the lime-cells, or in both. Owen, however, states, that these tubes are of two kinds, and in his paper, *On the Structure of Teeth, and the Resemblance of Ivory to Bone, as illustrated by Microscopical Examination of the Teeth of Man, and of various existing and extinct Animals*, in the *Transactions* of the British Association, 1838, he says there are "other substances entering into the composition of teeth, and presenting microscopic characters equally distinct both from ivory, enamel, and cement, and from true bone, and as easily recognizable."* To one of these structures in his *Odontography*, he applies the term *Vascular Dentine*, in contradistinction to the *Unvascular Dentine*, as he denominates the tooth-substance, consisting of lime-tubes and cells already mentioned. The essential character of this vascular dentine† consists in "the prolongation or persistence of cylindrical canals of the pulp-cavity" into this substance, and which "manifests itself under a variety of forms." To these canals he has applied the term "Medullary," from their close analogy with the so called canals of bone; they are straight and more or less parallel with each other; they bifurcate, though rarely; and when they anastomose, as in the megatherium, it is by a loop at or near the periphery of the vascular tissue." Such is their disposition in mammals and reptiles. But "in fishes, in which the distinction between the dentinal and osseous tissues is gradually effaced, the medullary canals of the vascular dentine though, in some instances straight and parallel, and sparingly divided or united, yet are generally more or less bent, frequently and successively branched, and the subdivisions blended together in so many parts of the tooth as to form a rich reticulation." They usually continue of the same size throughout, giving off the lime-tubes in their course, and in the megatherium may be seen "generally anastomosing in pairs by a loop, whose convexity is close to the origin of the fine ivory tubes, as if each pair so joined was composed of one reflected canal. Some, however, are continued across the fine ivory, and anastomose with the corresponding canals of the cæmentum."‡ The latter seem to have been already observed by Retzius, although without alluding to their peculiar contents, for in his description of the rough seal, *Phoca hirsuta*, Screb., he says, "in some parts these outermost branches pass from the principal tubes into the neighbouring tubes and cells of the cement;"§ and again, as to the walrus, *Trichechus rosmarus*, Lin., he says, "the outermost extremities of the

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* Muller, *loc. cit.* p. 3.

* See Owen, *loc. cit.* p. 137.
† See Introduction to *Odontography*, p. 17.
‡ See *Brit. Assoc. Trans.* p. 146.
§ See Retzius in Muller, p. 514, *et infra.*

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Zoology. tubes, or the outermost cells in the tooth-bone, communicate with the innermost cells of the cement: these communications are especially distinct in the root."*

The size of these medullary canals is, according to Owen, sufficient to admit the blood-globules, which cannot penetrate the lime-tubes on account of their delicacy, and therefore "the capillary circulation is confined to the pulp or medullary canals." There might seem to be some difference between Retzius and Owen as to the size of these canals, but such is not the case; for in immediate continuation of what has been just quoted, Retzius says, "Besides these (communications), there are also here seen some tolerably large tubes, which stretch up into the substance filling the interior (of the tooth), and which contain a reddish substance, probably dried blood. These larger tubes are very similar to the medullary canals in the dropped antlers of deer. I presume that they are small scattered remains of the pulp-cavity. Indeed it is very clear that the filling up of the pulp-cavity in the walrus is connected with a division of the pulp itself, which seems to be separated into a quantity of long threads, around which the little tooth corpuscules composing the filling matter seem to arrange themselves in the shape of small cones; these when cut transversely exhibit a hollow in the midst of a hollow from the edges of which passes in every direction a radiation of principal tubes." Owen further characterizes these medullary canals by their being in many cases surrounded with concentric lamellæ, and by the absence of any corpuscules;† but elsewhere he states, that the latter are present, as in some reptiles and mammals, and hence seems inclined to consider this as a fifth dental tissue. From what has been quoted, it is evident that Retzius saw these canals, but he seems to have considered that they resulted from the division of the pulp in process of filling up the pulp-cavity. Owen, on the contrary, speaks of them as prolonged or persistent canals of that cavity, in which processes of the pulp proceed into the tooth-substance, from the capillary vessels of which the earthy deposit is poured out into the lime-tubes arising from them, as they do also from the pulp itself; by which means the formation of the tooth-substance is more actively carried on. As to the object effected by those canals which communicate with the cells and canals of the cement, viz., that the tooth-substance thereby attains an additional mean of connection with the general system, they both agree.

The tubes and cells which have been now described are arranged, according to Müller, in a homogeneous, structureless substance: this, to which Schwann restricts the term "proper substance of the tooth," is considered by Purkinje and Raschkow to consist "at first of fibres variously curved, the convex sides of which touch and there concrete," whilst, at their concavities, chasms are left between them; these, as they increase in width, form "continuous canals which, arising at the periphery of the tooth-substance by numerous small curves, extend to the tooth-pulp and its cavity, and there terminate by open mouths."‡ It would seem from this description, as Schwann observes, that the tubes are merely the chasms in this substance. Müller, however, had already shown that such was not the case, and that the tubes have proper walls of their own; and it may be inferred that he considered the animal part of the interstitial substance to be cartilaginous, as, in speaking of the lime contained in it, he says, it is "either chemically connected with the cartilage, or deposited in it in some unknown way;" but beyond this, he does not advert to it. Schwann, however, after putting some of the tooth-substance into acid, till, by the abstraction of the earth, it had become pultaceous, discovered it to "consist of fibres, which could be here and there separated. These fibres were too thick to be the walls of the canals; they formed the entire substance."* He thinks they could not have been artificially formed, as they were too regular and smooth. It would rather seem that the tooth-substance is composed of these fibres consolidated together; that they are identical with those fibres by the union of which, according to Purkinje and Raschkow, the tooth-cartilage is formed, but that this union of the fibres is not so complete as to prevent their artificial separation. The fibres took the same course as the tubes in human teeth, and Schwann could no longer distinguish tubes between them.

The chemical composition of tooth-substance in the human subject is, according to Berzelius,

| | | |
|---|---|---|
| Animal substance and water of chrystallization of the earthy parts | 28·00 | in 100 parts. |
| Phosphate of lime | 61·95 | |
| Carbonate of lime | 5·30 | |
| Fluate of lime | 2·10 | |
| Phosphate of magnesia | 1·05 | |
| Soda, and a small quantity of salts of soda | 1·40 | |

In Pepys' analysis no mention is made of the fluate of lime, of the magnesia or soda. The teeth of the shark and carp, according to Lassaigne, consist only of phosphate and carbonate of lime with animal matter; but in one of the upper pharyngeal teeth of the latter, Stromeyer detected magnesia.

### *Of the Cement.*

This substance was first discovered by Blake in the teeth of ruminant and graminivorous beasts, and described by him under the name *Crusta petrosa*, as harder and more brittle than the bony part, but less so than the enamel of the tooth. He also states, that it is deposited on the outer side of the same membrane, which on its inner surface had previously secreted the enamel. Tenon called it *Cortical Osseux*, believing it to be produced by ossification of the membrane which had invested the tooth. The term *Cement*, by which it is now generally known, was applied to it by Cuvier from its connecting the several pieces of which semi-compound and compound teeth are made up. But taken merely in the sense of a connecting medium of parts of the same tooth, the term is incorrect, for it overspreads the surface of almost all kinds of teeth, and is only a less constant constituent than tooth-substance. If, however, its more important office, that of connecting the tooth with the general system, be intended, the designation is very appropriate.

The Cement blackens by exposure to heat more readily than tooth-substance, and though softer than either it or enamel, is stated by Cuvier to dissolve in acids

* See Retzius, *loc. cit.* p. 518.
† See *Brit. Assoc. Trans.* p. 137.
‡ See Raschkow, *Diss.* p. 6

* See his *Mikroskopische Untersuchungen, &c.* p. 124.

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with much greater difficulty, an assertion supported by Purkinje and Fraenkel's observation, that a dog's tooth immersed for a night in dilute muriatic acid had its crown almost converted into mucus, whilst the root preserved a cartilaginous consistence. Opposed to this, however, are the experiments of Retzius both on human and horse teeth, in which sometimes the tooth-substance, sometimes the cement, was first dissolved, and hence he concluded that a less speedy solution in acid is not to be held as a distinct character of cement. Cuvier states, that in the greater number of species, the cement has no apparent organization, and resembles a kind of tartar, which may chrystallize on a tooth; he had however found in the guinea-pig a multitude of regularly disposed pores in it. Recent inquiries have entirely disproved this assertion, and shown that, so far from not having any "apparent organization," the cement is highly organized, more so even than the tooth-substance, and more closely resembling bone. Berzelius, as quoted by Retzius,* appears to have been aware of its organized character, and speaks of it as a kind of bony lamella covering the tooth below the boundary of the enamel, "which lamella is first distinctly perceived after immersion in acid, when it can be scraped off, so that the tooth previously rough becomes smooth and glossy." Purkinje and Fraenkel describe it as a laminated substance, full of osseous granules. The observations of Retzius, however, show that the cement consists, as do the tooth-substance and bone, of cartilage and bone-earth, and that under the microscope the same cells or corpuscules are perceived as in true bone and most cartilaginous structures. It is acted on by boiling water less readily than tooth-substance, and retains some finer granules of earth after the tooth-cartilage is entirely deprived of them. In a thin slice of this substance, with the aid of a lenze, numerous closely approximated white spots, scarcely visible to the naked eye, are observed, which when more strongly magnified are found to be little cells full of earth, into and out of which pass numerous tubes, as in tooth-substance and bone, slightly expanding as they approximate to the cells, and giving them an irregular starlike appearance. The tubes are very freely connected with each other, in part directly, partially by branches from $\frac{1}{1000}$ to $\frac{1}{1500}$ of a Paris line in diameter, and in part by proceeding immediately from one cell to another. The cells are of an irregular form, some are elongated or almost tubular, and others of nearly equal width in every direction. Their mean size is about $\frac{1}{75}$ of a Paris line; and in a transverse section of a tooth they are seen arranged in parallel stripes or concentric rings, of which some are wider than others.

In the human tooth Retzius says that the cement commences by an extremely thin layer at the neck where the enamel terminates, and thence gradually increases in thickness to the extremity of the root; but that, in a recently perfected tooth, it is so thin that the cells in it are not visible, and itself appears only as a delicate membrane; in proportion, however, to the age of the tooth, and as its pulp-cavity is filled up, the thicker becomes the cement at the root of the tooth. Purkinje and Fraenkel also mention that, "in the incisive tooth of a man aged seventy years, they found the whole root surrounded with this substance, which at its extremity was very thick, and thence rising up, gradually attenuated, and reached the part where the enamel commenced; on one side it rose higher, and even covered a small part of the enamel, from whence it was easily removed as a thin layer.* In the horse, Retzius observed a molar tooth just ready to be cut covered entirely with cement; the same is always the case with the molar teeth of the elephant, and most probably of many other beasts. In the whole order of serpents, Owen states that the teeth are covered with cement; and in some fishes, as for instance the sharks, in which it acquires such density and transparency, that it almost resembles enamel. The form of the cells in cement varies, according to Retzius, very considerably in different animals, and even in the same animal. In the baboon they are triangular, round, and oblong, with pointed extremities; in the sheep, they resemble the netlike vessels of glands rather than cells, and are about $\frac{1}{25}$ of a Paris line in diameter; they are also remarkable for the large and numerous connections formed between them and the cells on the outer part of the tooth-substance: in the ox they are roundish, and in the horse oval, with a short diameter of about $\frac{1}{100}$ of a line: in the cement of the elephant's tusk some are oval, but the greater number round, and about $\frac{1}{115}$ of a line in diameter: in the seal they are lenticular; in the walrus almond-shaped, about $\frac{1}{150}$ of a line in length, and half so much in width; in the crocodile they are of a rounded starlike form: and in the *Balistes Vetula*, large and irregular. The connection of the tubes in the tooth-substance with those in the cement has been already mentioned; to which Retzius adds, that the cement on the root of the cuspid tooth of the lynx is perforated by numerous tubes, converging to the pulp-cavity, and that similar ones exist on the roots of the molar teeth, which canals probably contain the blood-vessels nourishing the pulp. In the walrus the tubes form numerous connections with the delicate terminations of those of the tooth-substance, and many larger canals, probably containing blood-vessels, run to the pulp-cavity: in the megatherium also, Owen mentions the existence of similar canals taking the same course.

The chemical composition of the cement is, according to the analysis of Lassaigne,

| | | |
|---|---|---|
| Animal matter . . . . | 42·18 | in 100 parts. |
| Phosphate of lime . . . | 53·84 | |
| Carbonate of lime . . . | 3·98 | |

### *Of the Enamel.*

The Enamel is a much less frequent constituent of teeth than the cement; "it is," as Owen observes, "more frequently absent than present in the teeth of the class of fishes; it is wanting in the entire order of ophidia among existing reptiles; and it forms no part of the teeth of the edentata, and many cetacea among mammals."† Even as regards its comparative extent in teeth where it occurs, it is much less, being restricted entirely, at least in simple teeth, to that part which rises above the edge of the gum. It has been called, from its glasslike appearance, and its external situation on the human teeth and those of predaceous animals, the *Vitreous Cortical substance;* but Blake objects to this term, and says that, as to its vitreous nature, nothing can be more erroneous, and proposes "to call it the *Cortex*

* See Retzius, *loc. cit.* p. 544.

* See their *Dissertation*, p. 7.

† See his Introduction, p. xxii.

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 *Striatus*, as such an appellation seems to coincide more with the nature of it."* On account of its great hardness and density, Purkioje and his pupils have designated it as the *Adamantine substance*. It has been however long since, and more commonly, known as *Enamel*, from its resemblance in general characters to that substance.

The Enamel is generally of a transparent white colour with a bluish tinge, but sometimes it inclines to brown or reddish. It is so hard as to emit sparks when struck with a steel; and if broken, "appears," as Mr. Hunter observes, "fibrous or striated, and all the fibres or striæ are directed from the circumference to the centre of the tooth."† It does not blacken externally when heat is applied to it, and only slightly within; but if the heat be sudden and not sufficient to penetrate the whole tooth, the enamel flies off in small fragments, whilst, on the contrary, if the heat be greater, pieces of enamel and tooth-substance burst away together. Mr. Hunter says, "it would seem to be an earth united with a portion of animal substance, as it is not reducible to quick lime till it has first been dissolved in an acid. When a tooth is put into a weak acid, the enamel to appearance is not hurt; but on touching it with the fingers, it crumbles down into a white pulp."‡ Berzelius observes, that after solution in acid the enamel leaves no cartilage, but merely a very insignificant brown tissue, which had been attached on its inner side, and "when thoroughly dried, it does not lose more than two per cent. by burning."§ And even Weber says "it possesses very little or no combustible animal matter, but consists almost entirely or entirely of earthy parts;" and "thus much is certain, if even a little animal substance is found in it, that can form no connecting whole; therefore if the earthy parts of the enamel are dissolved by acid, no animal substance presenting the form of the enamel remains."‖ These observations have doubtless been made on perfectly formed teeth; and as Owen justly remarks, "it is certain that the small proportion of animal matter which can be obtained from the enamel of a tooth, that has been completely formed and in use, does not yield any indication of its primitive form,"¶ and structure might be added: it is not surprising that the account of enamel should have been so unsatisfactory and incorrect, till the inquiries of Purkinje, Retzius, and others, upon growing teeth, had pointed out the true structure of this previously presumed to be inorganized structure.

The enamel, according to Purkinje and Fraenkel,** consists of simple fibres, having nearly the same direction as the tubes of the tooth-substance. They increase slightly in thickness from their interior to their superior extremities, and generally assume the form of quadrilateral prisms, which perhaps arises from mutual compression at the period of their formation. Each longitudinal fibre is connected with those adjacent by little transverse fibres, and makes more or less curves probably on one and the same plane, but no branches are given off. Retzius has measured these "little angular needles," as he calls them, and finds that they are about $\frac{1}{388}$ of a Paris line thick.†† The transverse lines are more or less distant, sometimes run directly across several prisms, sometimes alternately like the mortar streaks in a brick wall. How these transverse fibres are produced, Retzius is not satisfied, but supposes, if the enamel fibre itself be an inorganic mass surrounded with a thin organic capsule, that they really belong to it, and not to the enamel. With a magnifying power of 300, Retzius found in a transverse section of the crown of a tooth, the enamel fibres close set and of an hexagonal form like the cells of a honeycomb; the same appearance presented itself on the crown of an unused tooth, and the free extremities of the prisms were generally somewhat rounded.* Between the inner ends of the prisms and the surface of the tooth-substance upon which they rest, is the thin membrane which Berzelius described as a very insignificant brown tissue, but which, according to Retzius's observations, resists the action of water for a very long time, even many months, and with the microscope exhibits a quantity of close set little hollows, but no trace of fibres. These little hollows probably correspond to the "numerous small points and intervening little shallow but regular cavities in which the extremities of the enamel prisms terminate,"† and which Retzius says he distinctly observed on the surface of the tooth-substance of a human tooth. The enamel prisms thus fixed pass perpendicularly upwards towards the masticating surface of the tooth, whilst those on the sides pass more or less obliquely and horizontally as they descend towards the neck of the tooth; and Retzius says, that their outer extremity is larger than the inner, but scarcely visible without magnifying. In some teeth, with this general direction they also form various curves, which sometimes are parallel, but at others opposed, so that one end of a prism ends obliquely against another, which has already reached the surface. There are also found occasionally on the outer part some enamel fibres wedged in as it were, which do not pass down to the tooth-substance; such may be seen in the molar teeth of man, horse, and ruminant beasts. Owen considers the prisms of the enamel to correspond with the lime-tubes of the tooth-substance, and observes, "in the teeth of fishes the calcigerous tubes or fibres of the enamel, which ramify and subdivide like those of the dentine, have their trunks turned in the opposite direction, or towards the periphery of the tooth; so likewise, even in the human teeth, the analogous condition may be discerned in the slightly augmented diameter of the enamel fibres at their peripheral as compared to their central extremities."‡ On the outer enamel-covered surface of a human tooth numerous transverse parallel wavy projecting lines may be seen, which are so fine and close, that Retzius counted twenty-four within the length of a Paris line. They are most distinct and close on the outer surface of the incisive cuspid and single-pointed molar teeth, but less so on those which have many points. They also encircle the entire crown of all these teeth, but are less distinct on their inner surface. These lines Retzius supposes, from the examination of a fossil front horse tooth, in which being larger and less close, not more than four in a line's length, they were visible to the naked eye, depend on the enamel prisms being collected into numerous bands, of which the inner edge rested against the tooth- 

* See his *Essay on the Structure and Formation of the Teeth in Man, &c.* p. ix.
† See Hunter, *loc. cit.* p. 33.
‡ See in Retzius, *loc. cit.* p. 533.
§ *Ib.* p. 34.
‖ See Weber, p. 207.
¶ See his *Odontography*, p. xxiv.
** See their *Dissertation*, p. 19.
†† See *loc. cit.* p. 535.



* See *loc. cit.* p. 537.
† See *loc. cit.* p. 536.
‡ See his *Introduction*, p. xxv.



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substance, and the outer projected beyond the next following band. These lines were discovered by Leeuwenhoek, and supposed by him to be indications of the passage of the tooth through the gum. Retzius also describes* two peculiar appearances produced by longitudinal fracture or section of the enamel: the first consists of *brownish parallel streaks* which in unworn teeth surround the crown points of the tooth-substance, but on the sides, specially of those with wedge-shaped crowns, pass nearly parallel to the axis of the tooth; the second, composed of *short white*, generally *arched streaks*, broad in proportion to their length, which at the edge of the enamel opposite the neck are situated much outward, but in the crown stand turned towards each other.

The first step towards the discovery of the organic covering of the enamel prism, of the existence of which, even in the perfectly formed tooth, notwithstanding its extreme delicacy, there can be now no doubt, was made by Purkinje and Raschkow in their inquiries respecting the development of the tooth, which will presently be adverted to. They speak of "short regular fibres overspreading the interior of the enamel membrane, placed perpendicularly upon it, with their extremities of an hexagonal form, and to be considered as excretory organs or glands for the secretion of the corresponding enamel fibres." Schwann, however, has since examined and described them more fully; and according to his account, "if an incomplete tooth, either human or mammalian, that of a pig for example, be removed from the dental capsule, and immersed in dilute acid, it leaves after the solution of the lime from the enamel an organic substance, which can be separated from its connection with the proper tooth-substance. This has the form and size of the enamel previous to its treatment with the acid: it is very soft, and breaks readily in the course of the enamel fibres. When examined with a high magnifying power and depressed light, it is found to consist, like the enamel itself, of closely approximated prisms, which can be separated, and possess a distinct individuality."† Owen also observes, that "the enamel of the molar tooth of a calf, which has just begun to appear above the gum, and which can readily be detached from the dentines, especially near the commencement of the fangs, is resolvable into apparently fine prismatic fibres; if these fibres be separately treated with dilute muriatic acid, and the residue examined with a moderate magnifying power in distilled water, or, better, in dilute alcohol, portions of more or less perfect membranous sheaths or tubes will be discerned, which inclosed the earthy matter of the minute prism, and served as the mould in which it was deposited."‡

The earthy materials of the membranous enamel prisms just described have been very variously stated by different chemists, and no less different are the proportions given between inorganic and organized parts: thus whilst Pepys could find no animal matter in human enamel, and Berzelius only 2 per cent., Lassaigne mentions 20, Josse 24, Fourcroy and Vauquelin 27·1, and Morichini 30 per cent. The following are the analyses§ of 100 parts of enamel, according to—

* See *loc. cit.* p. 538.
† See Schwann, *loc. cit.* p. 110.
‡ See his *Introduction*, p. xxiii.
§ See Weber, p. 208.

Berzelius.

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|---|---|
| Membraoous substance, water, and perhaps cartilage accidentally connected with the tooth-substance | 2·0 |
| Phosphate } of lime | 85·3 |
| Carbonate } of lime | 8·0 |
| Fluate } of lime | 3·2 |
| Phosphate of magnesia | 1·5 |
| | 100 |

Morichini.

| | |
|---|---|
| Animal substance | 30 |
| Lime | 33 |
| Magnesia | 9 |
| | 5 |
| Phosphoric and fluoric acids | 22 |
| Carbonic acid | 1 |
| | 100 |

### Of the Development of the Teeth.

This subject has of late years attracted considerable attention; and though Heusinger had theoretically placed the teeth in connection with mucous membrane, as one of its products, yet their actual development from that tissue had not been fully demonstrated till the careful observations of Goodsir. It has been attempted, however, to deprive him of the honour of the discovery by stating that Arnold had already declared the fact. That Arnold did publish a slight notice on the subject is perfectly true, but how far he had anticipated the observations of Goodsir, the following short and only notice in the *Salzburg Mediz. Chir. Zeit.* for 1831, will prove. "In the embryon, at the ninth week, may be perceived in both jaws, on the projecting edge of the gums, a proportionally pretty deep furrow containing ten depressions; a little later may be seen a flat surface, on which are many openings, communicating with small sacs, into which fine bristles may be passed. At the third month, the sacs of the second molars may be observed communicating with the cavity of the mouth by small holes. The openings of the remaining sacs are soon closed by the mucous membrane of the mouth. The sacs of the permanent molar teeth are also formed immediately from the mucous membrane of the mouth, partly at the fourth month of fœtal existence, partly towards the end of that period, and partly at birth." The following is an abstract of Goodsir's observations.* In the upper jaw of a human embryon of six weeks, between the lip and a semicircular lobe of a horseshoe form, (which is the primitive condition of the palate,) there is a deep, narrow groove, terminating on each side behind the lip by curving inwards on the soft mucous membrane. This groove, gradually widening, is divided by a ridge, the outer alveolar process, into other two, of which the outer forms the doubling of the mucous membrane between the lip and the outside of the alveolar process, and the inner the *primitive dental groove*, from the germs of the teeth appearing in it. The inner side of the ridge just mentioned is hollowed into three grooves with their concavities looking inwards, which are occupied by as many bulgings of the semicircular lobe, so that the one exactly corresponds to the other. Between the sixth and seventh week, a longitudinal portion is cut off from the inner posterior edge of the

* See his paper in *Edinburgh Medical and Surgical Journal* 1839, p. 1.

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semicircular lobe, as far as its middle bulge, and the posterior bulge is isolated and defined in form of an ovoidal papilla, which is the germ of the anterior milk molar tooth, and is "at this period a *simple, free, granular papilla*, like many others *on the surface of the mucous membrane* and skin." About the eighth week, the papilla of the upper milk cuspid tooth appears, and in the ninth week, on each side of the mesial line in front, the papillæ of the incisive teeth present themselves. At this time the primitive dental groove extends forward to the mesial line and the sides of the groove, before the anterior molar papillæ have been gradually approaching each other. During the tenth week the incisive papillæ are nearly stationary, but their anterior laminæ have somewhat increased; "processes from the sides of the primitive dental groove, particularly the external one, approach and finally meet before and behind the papilla of the anterior molar, so as to inclose it in a follicle, through the mouth of which it may be seen." A similar follicle is now formed around the cuspid tooth, and the papilla of the second molar appears behind the anterior one. During the eleventh and twelfth weeks septa pass between the outer and inner edges of the groove, where the incisive papillæ are; so that they soon sink into follicles: "the posterior molar papilla also increases in size, its follicle is formed, and a portion of the primitive groove is left behind. In the following week the last mentioned follicle is perfected, and the different papillæ, instead of remaining as hitherto, simple, rounded, blunt masses of granular matter, assume peculiar shapes," somewhat corresponding to the future teeth. At this time the papillæ grow faster than the follicles and protrude from their mouths, which latter are simultaneously "undergoing a change, which consists in the development of their edges so as to form opercula, which correspond in some measure with the shape of the crowns of the future teeth; on the incisive follicles there are two, on the cuspid three, and on the molar four or five opercules, each corresponding with a tubercle, whilst their edges correspond with the grooves on the grinding surfaces of these teeth. Now (at the fourteenth week) the inner lip of the dental groove or outer edge of the palate, which has been increasing, is large enough to meet and apply itself to the outer lip or ridge, which has also increased. The follicles now grow faster than the papillæ, so that the latter seem to recede into them. The primitive dental groove, now containing ten papillæ in their follicles, may be also called the "secondary dental groove," as it provides for the production of all the permanent teeth except the front molar, the preparation for which is manifested "by the gradual appearance of a little depression in the form of a crescent immediately behind the inner opercule of each of the milk-tooth follicles." About the fifteenth week the opercula close the mouth of the follicles, but without adhering. "The lips and walls of the secondary groove now begin to adhere from behind forwards, the opercula and every part of the groove, with the exception of the ten depressions for the permanent teeth, becoming rough, flocculent, and adherent. The follicles have now become *sacs*; the papillæ, the *pulps* of the milk-teeth, and the crescent-formed depressions vacant *cavities of reserve* to furnish delicate mucous membrane for the future formation of the *pulps* and *sacs* of the *ten* anterior permanent teeth." . . . . . "The papillæ of the milk-teeth from the time their follicles close, become gradually moulded into their peculiarly human form:" the sacs grow more rapidly than the pulps, leaving an intervening space, in which is deposited a gelatinous granular substance, at first in small quantity, and adherent only to the proximal surfaces of the sacs, but ultimately, about the fifth month, closely and intimately attached to the whole interior of these organs, excepting a space around the base of the pulp, which space retains the original grey colour of the inner membrane of the follicle. Such then is the excellent description which Goodsir has given of this interesting process; and without detraction from Arnold's previous observations, with which he was unacquainted, he is as fully entitled to the merit of the discovery as Purkinje to that of the tubular structure of the tooth-substance already described by Leeuwenhoek. Owen has also occupied himself on this subject in fishes, and has admirably shown the parallelism between these transitional stages from mucous membrane to tooth-pulp in higher animals, and pointed out different individuals of this class in which the development has either ceased at one or other of these stages, or, like the former, passed through the whole series. He says, "In all fishes, as in other vertebrate animals, the first step is the production of a simple papilla from the free surface of either the soft external membrane, as in the young *Pristis*, or of the mucous membrane of the mouth, as in the rest of the class. In these primitive papillæ there can be very early distinguished a cavity containing fluid, and a dense membrane, *membrana propria pulpi*, surrounding the cavity, and itself covered by the thin, external, buccal, mucous membrane, which gradually becomes more and more attenuated as the papilla increases in size. In some fishes, as the sharks and rays, the dental papillæ do not sink into the substance of the vascular membrane, from which they grow, but become buried in depressions of an opposite fold of the same membrane; these depressions enlarging with the growth of the papillæ, and forming the cavities or capsules in which the development of the tooth is completed. They differ from the capsules of the matrix of the mammiferous tooth in having no organic connection with the pulp and no attachment to its base." . . . . "Here, therefore, is represented, on a large, and as it were persistent scale, the first and transitory papillary stage of the development of the mammalian teeth." . . . . . . "In many fishes, as the lophius and the pike, the dental papillæ become buried in the membrane from which they arise, and the surface to which their basis is attached becomes the bottom of a closed sac. But this sac is never lodged in the substance of the jaw, the development of the tooth being completed in the tissue of the thick and soft gum, or mucous membrane, from which the papillæ were originally developed. The ultimate fixation of the teeth so formed is effected by the development of ligamentous fibres in the submucous tissue between the jaw and the base of the tooth, which fibres become the medium of connection between those parts, either as elastic ligaments, or by continuous ossification. Here we have the second step in the development of the mammalian tooth represented, viz., the imbedding of the pulp in a follicle of the mucous membrane; but the eruptive stage of the tooth takes place without any previous inclosure of the follicle and pulp in the substance of the jaw." In "many other fishes, the formation of the teeth presents all the usual stages which have been observed to succeed each other in the dentition of the highest organized animals; the papilla



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sinks into a follicle, becomes surrounded with a capsule, and is then included in a closed alveolus of the growing jaw, where the development of the tooth takes place, and is followed by the usual eruptive stages."*

Having thus described the development of the tooth-germ from the mucous membrane to the period of its inclosure in a proper capsule, it remains to inquire into the evolution of the germ, upon which depends the production of the different structures composing the tooth.

The *Dental Follicle*, or *Capsule*, contains all the formative parts of the tooth. Mr. Hunter says it is "without vessels," but Purkinje and Raschkow speak of it as surrounded by a dense vascular net-work, given off from the surrounding vessels, and especially at the base. They describe it as consisting of very soft fibres, intermingled with much granular parenchyma, and not at first connected with the gum. Its internal surface is smooth, resembles a serous membrane, and is entirely free, except at the attachment of the dental germ, which corresponds to the entrance of the principal vessels and nerves. Between the interior of the capsule and the germ, when the latter has scarcely commenced, is found a nucleus almost globular, externally, for a short time, tuberose, and containing within a peculiar parenchyma, which probably at first, and previous to evolution, consists of the formative granular matter common to all fœtal organs; these granules gradually assume an angular form, variously connected by threads of cellular tissue, producing a kind of actinenchyma like that of plants. Between the capsule and the nucleus which it surrounds, and also between the latter and the germ, there is a peculiar fluid, like mere lymph, containing neither granules nor any thing else. This is doubtless the "mucilaginous fluid, like the synovia in the joints," mentioned by Mr. Hunter. This nucleus Purkinje and Raschkow call the adamantine (enamel) organ, as subsequently it is converted into the membrane by which that substance is produced. As the germ grows, it makes an impression in the globular mass of the adamantine organ, which continues deepening, and as the germ rises it spreads out above, and narrowing at the base, is completely surrounded by the hollowed adamantine (enamel) organ, which becomes cap-shaped, and can be removed from the germ without rupture, being separated from it, as when globular, by lymph-like fluid. The inner surface of the adamantine cap which thus incloses the germ, exhibits a peculiar organ, consisting of short, equal fibres, overspreading its surface like a covering of velvet, and totally distinct from the stellated parenchyma considered to be the adamantine (enamel) pulp, with which, however, it is at first most closely connected, and from a direct metamorphosis of which it arises. Gradually, however, it disengages itself from the pulp, is connected only by a few threads, and then justly acquires the name of a proper membrane, the adamantine (enamel) membrane, the greater part of which can be separated from the pulp, except in the hollows of the molar teeth, where the parenchyma remains, up to the time of the eruption of the tooth, but neither then, nor at any preceding period, does it exhibit a trace either of vessel or nerve.† By a close inspection of the inner surface of the enamel membrane it is seen to consist of almost equal sized corpuscules in regular rows, of an hexagonal form, but visible only with a lens, and the middle of each presents a little round elevation; these are, however, merely the extremities of the short fibres of the membrane, which being compressed assume this form, as they do in plants. The enamel organ is always less distinct at the lower part than elsewhere, as the enamel continues to be there produced, and the organ itself to grow till the completion of the enamel covering.* The dental germ is doubtless the produce of the internal wall of the dental capsule, as the parenchymatous substance itself is inseparably connected with the capsular membrane, and the origin of the vessels and nerves of both is the same. At first the parenchyma of the germ consists of nearly equal globular granules, in which neither vessel nor nerve is visible; they appear, however, but only after a considerable time, and when vessels are seen then also nervous filaments are detected; and it may be observed that in no part of the body are the extreme branches of the latter better seen than in the tooth-pulp. From the very earliest appearance of the germ the surface of the pulp is found covered from its base to its tip with a proper, tough, very pellucid membrane, devoid of any peculiar organization, which, as the formation of the tooth-substance commences in it, must have been antecedent, and is therefore called the *præformative membrane*.† Within the parenchyma no vessels are observed till the formation of the tooth-substance begins, when numerous little trunks, communicating with each other, enter the pulp and pass to the very spot where this formation has just begun, and there form a dense net of capillary vessels; but where this process has not commenced, the præformative membrane alone is found, but no vessels. Immediately beneath and upon the membrane are imposed the globular granules of the parenchyma, regularly arranged for the most part longitudinally, but some at right, and others at slightly acute angles. The evolution of the gum being now much advanced, and the time for the production of the tooth-substance approaching, upon its top, and in the immediate neighbourhood, spots like tumuli are observed on the præformative membrane, which, probably, at a subsequent period, are converted into the wavy ridges on the outer surface of the dental substance, upon which the enamel fibres have a firm resting-place. Simultaneously also, the tooth-substance begins to form beneath the coronal surface of the membrane, and thence descend to the coronal pits, and also to the root of the tooth. Mr. Hunter's account of this process is very brief; he says that "the beginning of the ossification *upon* the pulp is by one point or more according to the kind of tooth," and "as the ossification advances it gradually surrounds the pulp till the whole is covered by bone; and while the ossifications advance, that part of the pulp which is covered by bone is always more vascular than the part which is not yet covered." But, he concludes, "how the earthy and animal substance of the tooth is deposited on this surface of the pulp is not perhaps to be explained."‡ Blake, in treating of the same subject, says, "as the bone of the tooth increases in thickness, the pulp is proportionally diminished, and seems as it were *converted into bone*;" and after noticing the slight connection between this bony covering and the pulp, observes, "when the shell (of bone) is removed, the pulp appears covered with a very delicate membrane, in which the vessels

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* See Owen, *loc. cit.* p. 14. *et infra.*

† See Raschkow, *loc. cit.* p. 2. *et infra.*

* See Raschkow, *loc. cit.* p. 4.

† *Ib.* p. 5.

‡ See Hunter, *loc. cit.* p. 88.

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form a net-work. This seems to be a propagation of the periosteum which enters the canal of the jaw along with the vessels, and probably from whence are derived the bony lamellæ of which a tooth consists."* This is doubtless the appearance which Bell describes as "the proper membrane of the pulp," but it is most probably only "the dense net of capillary vessels" upon the surface of the pulp itself, described by Purkinje and Raschkow, when dentification has commenced, and certainly not to be confused with the præformative membrane, which is external to the tooth-substance, whilst Bell's "proper membrane" is within it. Returning to Purkinje and Raschkow's account, it appears that the tooth-substance, at first consisting of fibres variously curved, their convex surfaces touching and then coalescing, becomes hard and bone-like. The fibres upon the top spread in every direction, but on the sides the longitudinal direction prevails; whilst undulatory fibres, also touching, but leaving between them spaces between their concavities, pass in every direction from the crown to the root. Occasionally their extreme points still remain soft, but the other parts very speedily harden, unlike the enamel, of which the fibres, long after they are deposited, continue soft, and are broken down without difficulty. Whilst these are formed, the præformative membrane acquires an almost stony hardness, except at the edge of the recently formed tooth-substance, where it is soft and easily cut. So soon as one layer of dental fibres has been deposited between the parenchyma of the germ and the præformative membrane, now also ossified, the same process is continued from without inwards, the parenchyma supplying the material, at the same time gradually decreasing, and withdrawing into the dental cavity, which also contracts as the tooth-substance increases. The convex curves, increasing in breadth as they pass from without inwards, form by their approximation continuous canals, which, beginning at the periphery, stretch inwards, with numerous delicate undulations, to the dental pulp and cavity, where they terminate in open mouths, and are thus continued by the addition of new fibres till the perfection of the tooth, when, according to Blumenbach, they are closed by a somewhat different substance, yellow and sub-pellucid. Whilst this process is going on, the tooth-germ increases below, lengthening to form the root, and, if there be two or more fangs, divides correspondingly; these, as the tooth-substance is developed, appear as wide canals full of tooth-pulp projecting from the cavity, but as the formative process is continued they also are inclosed in tooth-substance, diminish in size, and, when fully developed, have only very small apertures for the transmission of vessels and nerves. From this account, it certainly appears that Purkinje and Raschkow do not consider, as has been stated, any thing like a glandular function as performed by the pulp, for they state distinctly, that after the appearance of tumuli on the præformative membrane, "immediately *beneath* the membrane, the proper tooth substance commences," . . . "the parenchyma of the germ supplying the material;" which expressions cannot be imagined to mean that the tooth-substance is secreted either by the membrane or by the parenchyma." As to the simultaneous appearance of vessels and the ossification of the præformative membrane and pulp, they observe this circumstance presents an analogy with the formation of bony substance (bone), nets of blood-vessels being than visible when the proper earthy substance of the bone is deposited."* Schwann is disposed to agree with the old opinion that "the tooth-substance is the ossified pulp," and considers the fibres of which the proper tooth-substance (his intertubular substance) consists, were originally cylindrical cells, which, lengthening and filling with organic matter, become at last solid and bony; and in support of his opinion he says "the cylindrical cells of the pulp have about the same thickness as the solid fibres of the tooth-substance, and the same course; and as they plainly belong, on the one hand, to the pulp, on account of their resemblance to the cylindrical cells which are still attached to the remaining surface of the pulp, and as they remain, on the other hand, as firmly connected with the tooth-substance as with the pulp, I imagine that here a transition takes place, and the cylindrical cells are only the early condition of the tooth-fibres."† The opinion of Owen, that "the principle of the dentary development is affected by *deposition in the substance*, not by *exudation without the substance*, of a pre-existing pulp," does not appear to differ materially from that of Schwann, whilst both agree in considering the cylindrical cells as subsequently becoming ossified and forming the tooth-substance. This similarity in the result of Schwann's observations on the pulp of a pig, and those of Owen on a fœtal shark, *Carcharias*, is as curious as the simultaneous rediscovery of the tubular structure of the tooth-substance by Purkinje and Raschkow and Retzius; for Owen observes that it was subsequent to his communication to the French Academy that he perused Schwann's work; and "thus the theory of dentification, which he applied analogically from observation of the process of the shark to the same process in the higher vertebrate animals, is established, *ex visu*, by one of the most accurate and experienced micrographers of the present day."‡

Simultaneous with the formation of the tooth-substance is that of the enamel; but how this is effected has been much disputed. Mr. Hunter says, "upon the inside of the capsula, and adhering to it, is another pulpy substance, opposite to that already described," "in contact with the pulp of the tooth-substance, and afterwards with the new formed base of the tooth: whatever eminences or cavities the one has, the other has the same, but reversed; so that they are moulded exactly to each other;" and he proceeds, "the enamel appears to be secreted from this pulp, and perhaps from the capsula which incloses the body of the tooth;" "it is a calcareous earth, probably dissolved in the juices of our body, and thrown out from these parts which act here as a gland. After it is secreted, the earth is attracted by the bony part of the tooth which is already formed; and upon that surface it chrystallizes."§ Blake does not agree with Mr. Hunter as to the formation of the enamel by the pulp: he says, "the membrane which deposits enamel does not adhere to, but loosely surrounds the body of the tooth;" "in proportion as the first part of the cortex striatus is chrystallized, that portion of the membrane which formed it becomes thinner, less vascular, and at length having performed the particular function for which it is destined,

* See Blake, *loc. cit.* p. 7.

* See Raschkow *loc. cit.* p. 6. *et infra.*
† See Schwann, *loc. cit.* p. 124.
‡ See Owen, *loc. cit.* p. 38.
§ See Hunter, *loc. cit.* p. 94, *et pass.*

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is totally wasted or absorbed."* Purkinje and Raschkuw describe the enamel as being formed by the short, perpendicular, hexagonal prisms or fibres on the interior of its membrane, and which they hold to be excretory organs or glands, destined for the production of a corresponding enamel fibre. But "how are these enamel prisms produced?" inquires Schwann: "according to Purkinje and Raschkow, the exterior of the tooth is covered with a proper (the enamel) membrane, the inner surface of which is formed of short hexagonal fibres, placed vertically on it, and turned towards the enamel, so that every fibre of the membrane corresponds to an enamel fibre. If a portion of the enamel membrane, by which these fibres are produced, particularly that part nearest the root of the tooth, be examined, the characteristic nuclei and their nucleoli are easily perceived lying in a finely granular substance. In many parts this granular appearance is seen to be produced by granular cells, in which each nucleolus lies, surrounded by a round halo of fine granules, which is known to be the type of most elementary cells. Some of these cells elongate themselves in different directions into very delicate fibres, and seem to be young cellular tissue cells, but most are round. The fibres or prisms which are directed towards the enamel fibres assume, according to Raschkow, on account of their close approximation, an hexagonal form. They seem to be very similar to the epithelium cylinders of mucous membrane, except that throughout their whole length, so far as they project from the subjacent membrane, they are prismatic. I might, therefore, consider them only as elongated cells. When fresh, they contain a very distinct cell with its nucleus; they lie very close together above, but at that part of the membrane opposite the root of the tooth, they are much fewer, and stand singly, so that here also we can perceive the structure of the subjacent membrane, and I suppose that the above described round cells are the primary condition of these prismatic cells. In what relation then do these prismatic cells of the enamel membrane stand to the enamel prisms? Purkinje and Raschkow consider each fibre of the enamel membrane to be a secreting organ, a gland, and that it secretes the corresponding enamel fibre. According to my altered views of the growth of inorganized tissues, this hitherto very interesting explanation loses very much of its probability. Many other explanations may be given, but I am not yet able to decide which is the correct one." Some of these he mentions, but the one he thinks "most probable, is that the prismatic cells of the enamel separate from it, and unite with the already formed enamel, whilst at the same time either their cavities are filled with lime, or they become ossified throughout their entire thickness, as previously they had been filled with an organic substance. By this view of the subject the formation of the enamel is brought into correspondence with the growth of other inorganic tissues."† So soon as the tooth-substance has begun to form from the crown towards the root of the tooth, each fibre, imposing itself on the now indurated præformative membrane, begins to deposit successively the primitive part of each enamel fibre, which, by the aid of a microscope, are seen to be disposed in transverse strata. At this period an organic lymph seems to be produced by the parenchyma of the enamel membrane between these prismatic glands, penetrating and softening their substance, which afterwards, probably by some chemico-organic process, commences its connection with earthy matter, thus forming the animal base of the enamel, which can be rendered visible, however, only under the microscope, on account of its small quantity and delicacy, if the earth be abstracted by acid. The gradual conversion of this organic fluid, which is probably "the mucilaginous fluid, like the synovia in the joints, between this (the enamel) capsule and the pulp," mentioned by Mr. Hunter, seems to have been observed by Rousseau in 1827. He says, if the capsule of the tooth-sac upon the crown be separated, and its inner surface examined with a microscope of three or four lines focus, a vast quantity of very minute vessels are perceived of nearly equal transparency, by which the field is covered: they are very regularly arranged in rows, mostly parallel to the base of the crown, and hence rise up in layers one upon the other; they contain at first a transparent fluid, which subsequently becomes milky and thick; and he holds that when this is poured out on the surface of the tooth-substance it becomes enamel.* It may also be added that Mr. Hunter observed that the enamel "at its first formation is not hard," and that Blake stated "the earthy matter (the enamel) is at birth so soft that it could be scraped off with the nail of the finger." In explaining the formation of the various curves of the enamel-fibres, Purkinje and Raschkow suppose that, during the production of the enamel, its membrane, by certain trivial movements, alters the position of its fibre, whilst, on the one hand, as the enamel thickens, it yields, and is dilated outwardly, and on the other, by following the curves of the several enamel fibres in the lateral and longitudinal direction of the tooth, it suffers slight change of position in single or continuous parts. In those teeth, of which the crowns only are covered with enamel, the organ producing it has definite limits, and can be removed like a cap; but in such teeth as have an unlimited growth, to wit, the incisive of gnawing animals, the tusks and teeth of pachydermatous and ruminating animals, the enamel is not so strictly defined; hence at the beginning it is supposed that such limits are wanting to the enamel membrane, and that no cap is formed. The enamel membrane in this case, especially after the eruption of the tooth, presents the appearance of a more or less broad belt, which surrounding the basilar part of the tooth is forthwith converted towards the crown into an osseous membrane, at the root is continually produced, whilst its middle part deposits fresh enamel. Wherever the tooth is most rubbed, the enamel is more largely deposited, and this almost always takes place on the points of the crown. From what has been stated, it appears that the formation of the tooth-substance and of the enamel takes place in opposite directions: for, on the one hand, the pulp of the tooth-germ is covered with fibres of tooth-substance, and when a layer is completed the pulp seems to retract inwards, the increase of the tooth-substance being therefore periphero-central; whilst, on the other hand, the first layer of the enamel touching the tooth-substance is inmost, whilst all the others, being successively superimposed on it, approach the periphery, towards which the enamel retires; its direction is therefore centro-peripheral.†

* See Blake, *loc. cit.* p. 16.
† See Schwann, *loc. cit.* p. 120.

* See his *Anatomie Comparée du Système Dentaire, &c.* p. 208
† See Raschkow, *loc. cit.* p. 8.

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As regards the cement, which is always last formed, Purkinje and Raschkow observe that this takes place after the enamel is perfected, at which time its membrane disappears, or is in some other way transformed. If the enamel-pulp, which is primarily situated close to the membrane, does not perish with it, perhaps the pulp is preserved for the deposition of the cement. But if this disappear together with the membrane, there remains only the capsular membrane, which, at a later period, when the cement begins to form, doubtless coalesces with the periosteal lining of the alveolar cavities. This, however, does not throw any obstacle in the way of its producing the cement, inasmuch as the granular and canalicular structure of the cement exhibits great resemblance to the true osseous structure.* It now only remains to speak of the pulp or germ of the tooth; this, according to Schwann's observations, "agrees with all other tissues of the fœtus, as also with cartilage in being made up of cells; it is distinguished, however, in consistence from mammalian cartilage, because the quantity of cytoblastema, to which the mammalian cartilage owes its hardness, is very small, since at least the cylindrical cells of the surface of the pulp lie close together. In this respect the pulp is more nearly approximated to certain cartilages of the lower animals, in which the cytoblastema is also in smaller quantity, and the consistence of the cartilage is specially produced by thickening of the walls of the cells. Whether, in the supposed transition of the cells of the pulp in the tooth-fibres, the filling up of the cavities is effected by thickening of the walls of the cells, I know not, as I have not actually observed this transition. When it really happens, the hollows of the cells actually and entirely disappear, so that thus no cartilaginous corpuscules remain. From the observations of Retzius, however, we must suppose that some cells do still retain their cavities, and are even converted into star-like cells, as Retzius noticed actual bone corpuscules in the tooth-substance. If then the uppermost layer of the pulp, consisting of cylindrical cells, be converted by ossification into tooth-substance, so must the subjacent round cells in the parenchyma of the pulp first become cylindrical, the vessels of this layer be obliterated, and then also the layer become ossified."†

### Of Cartilaginous Tissue.

*Tela Cartilaginea*, Lat.; *das Knorpelgewebe*, Germ.; *le Tissu Cartilagineux*, Fr.

The term cartilage, as Bichat observes, has been too vaguely employed, designating, in its common acceptation, bodies of which the organization is entirely different: thus, for instance, the compound structure connecting the bodies of the spinal bodies, known as the intervertebral substance, and which has not any character of cartilage, was included in cartilaginous tissue, till separated from it by Bichat; and it is rather surprising that it should have again been included as a species of cartilage by Weber.

Cartilage exists under two conditions—in the one it remains cartilage throughout life, but in the other it is converted into bone; hence Miescher distinguishes two kinds, the Permanent and the Ossescent Cartilage.

* See Raschkow. *loc. cit.* p. 10.

† See Schwann, *loc. cit.* p. 125.

*Permanent Cartilage* is found where a certain degree of firmness is required to preserve the form of a part, but which for various causes is necessarily flexible and elastic; such are the cartilages of the auricle, of the epiglottis, and the upright cartilage on the upper edge of the arytænoid cartilage of cattle and swine. These cartilages are of a lustreless, dingy-yellow colour, and almost of a spongy texture. "Under the microscope, they present," according to Miescher, "a very regular opaque net-work, consisting of small round meshes, filled with an homogeneous pellucid substance, and each, for the most part, containing a corpuscule either roundish or oblong."* They are never converted into bone, and Miescher states that after boiling the cartilage of a pig's ear for thirty-six hours, much grease and scum rose, the water gradually assumed a yellow tinge, and the cartilage dissolved; and on evaporation there was left a dusky mass, not cohering into jelly, nor glutinous, but rather greasy to the touch. This account, as regards opacity and absence of jelly, corresponds with the observations of Weber.

There are, however, many instances in which permanent cartilage has not the dingy-yellow colour and spongy texture just mentioned, but has the beautiful bluish-white, transparent, and seemingly textureless character, ascribed to the ossescent kind. This is the case when it really supplies the place of bone, as in the cartilaginous skeleton of the cartilaginous fishes, the head ring of the cuttle-fish and other cephalopodous molluscs, and also probably the cartilaginous hull of the beautiful *Vellella*, upon which it hoists its tiny sail: thus indicating, as it were, the transition towards bone; which view is further supported by many parts of cartilaginous fishes containing a more or less quantity of phosphate of lime, though still very small in comparison to the proportion of that salt contained in bone.

The *Ossescent Cartilage* is, according to Miescher, that kind which either partially or entirely forms tubes, or becomes the direct connector of bones, or overspreads the surface of joints—such are the cartilages of the nose, Eustachian tubes, larynx, and windpipe; those of the ribs and breast-bone, the cartilaginous pulleys on the bending surfaces of the fingers and toes, and the cartilages covering the ends of bones. These all, however, notwithstanding their very different disposition and use, agree in appearance, structure, and convertibility into bone. The ossescent cartilages are of a white colour, most generally tinged with bluish, especially in young animals, and nearly all exhibit the beauteous iridescent appearance of mother-of-pearl. They are all slightly compressible, but inextensible; and are elastic in various degrees, the elasticity mainly depending upon the strength of the membrane by which they are invested, as, when that is stripped off, they easily break. The cartilage covering the articular ends of bones is easily separated from them even before ossification of the epiphyses, by maceration for a little time in any acid. When broken transversely they exhibit a fibrous appearance, which was first described by Dr William Hunter.† And, according to an experiment of De la Sône,‡ the articular cartilage on the head of the thigh bone, after boiling, showed an immense number of little fibres

* See his Inaugural Dissertation *De Ossium Genesi, Structura et Vita*, p. 27.

† See his paper in *Phil. Trans.* 1748, p. 314.

‡ See *Mémoires de l'Acad. Roy. de Paris.* 1752, p. 171

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Zoology. closely connected and implanted vertically upon the bone, just as the enamel-fibres are fixed upon the tooth-substance. Weber also observed the same appearance after having abstracted the earthy matter from the head of a thigh bone by muriatic acid; and says, that after long maceration, if the cartilage, either wet or dry, be broken, the same fibrous appearance is observed. Miescher, however, states that "under the microscope this appearance is entirely lost, and that nothing is seen but an homogeneous pellucid substance, with ovate corpuscules, the latter disposed in clusters, with their long axis placed transversely, as very distinctly seen in the thick cartilage covering the knee-cap, and hence giving rise to the fibrous appearance."* Herissant observed that human costal cartilages, after long maceration in water, separated into numerous little white leaves or plates, of which the convex front edge was thicker than the hinder concave edge; in the horse, however, no separation into plates occurred, but a cellular structure exhibited itself.† Miescher states that a transverse section of the costal cartilage presents on the edge the usual dusky ovate corpuscules pretty closely set, and forming the shell, whilst towards the centre they increase in size, are more closely approximated, and seem to be here and there confluent, still, however, retaining their dusky colour and distinct boundaries. Some, especially those corpuscules which are older, have internally a fibrous tissue, easily distinguishable by the naked eye, and seemingly connected with the blind extremities of vessels. The supposition that they were medullary cells was disproved by their not being removed by washing, and by their non-conversion into soap by the application of cold caustic potash; hence Miescher considers them only as larger corpuscules.‡ The nasal, laryngeal, and tracheal are precisely similar, with more or less varying corpuscules.

All these cartilages, excepting perhaps those of the Eustachian tubes and nose, are convertible into bone, and even with regard to the nose, Miescher holds that the little bones on the intermaxillaries of the swine's snout are ossified cartilages, an opinion which has some support in the corresponding bony character of the tubular nostrils of some birds. The larynx of some beasts, as monkeys, &c. in its adult state is bony; the larynx and windpipe of the whole class of birds is made up of bony pieces and rings; the costal cartilages in many beasts contain large quantities of earthy matter, in birds are converted into distinct bones, as also the corresponding disc of the shield of most chelonian reptiles; in adult birds the cartilaginous junction of the pelvic bones with the spine always ossifies, whilst in reptiles the pubic symphysis is ossified very early. Even in the human subject parts of the laryngeal cartilages become bony, and in old people the costal cartilages also, and by no means unfrequently the cartilaginous junction of the pelvic bones is ossified, so that the pelvis becomes truly one single bone; and still more rarely the articular cartilages are completely converted into an ivory-like bone in very old persons; the latter, however, may perhaps be a morbid condition, and not merely resulting from the continuance of the ossifying process. From all these circumstances the analogy between cartilage and the animal matrix of bone is very probable, for if both structures are capable of producing bone, it is a fair presumption that the structure of both is similar, if not indeed the same, which modern discoveries appear to prove decisively.

All cartilages are enveloped in a dense fibrous membrane, which serves as a bed for the ramifications of vessels prior to the entrance of their minute branches into it; which branches, with but few exceptions, are too small to convey the red particles of the blood. Their existence, however, cannot be doubted from the microscopic observations of Howship and Miescher; to which may be added, that if a section of cartilage be made, there is always an exudation of fluid upon the cut surface, very distinct, although extremely minute. Upon this membrane, which is called the *Perichondrion*, principally depends the strength and infrangibility of the cartilage, for when stripped off, the latter breaks with little difficulty, although previously it had been very tough. From the experiments made by Haller, of introducing sulphuric acid into the hip-joint, and that acid and also muriate of antimony into the knee-joint, without producing pain, it has been presumed by some that cartilage has no nerves; this, however, cannot be admitted, for not only is it contrary to the existence of all organized structures, but the acute pain which ensues under certain diseased states of cartilage proves the contrary.

The *Chemical Composition* of cartilage, according to Chevreul, consists of two-thirds its weight of water and one-third of dry animal matter; hence its milky whiteness and flexibility, for as it dries it becomes transparent and brittle. Allen says that cartilage is convertible into jelly with the addition of one part of phosphate of lime in 100. This, however, is denied by John Davy: he found in 100 parts of articular cartilage 55·0 of water, 44·5 of albumen, and 0·5 of phosphate of lime; which statement is confirmed by the observations of Weber.

### *Of the Development and Structure of Cartilage.*

The discovery which, within the last few years, has been made, by the assistance of the microscope, of the true structure and growth of cartilage, has become still more important by the close harmony which Schwann has shown to exist between it and vegetable tissue. For although Purkinje, Valentin, Müller, and others, had declared the cellular structure of many animal tissues, and Valentin had even stated that, in the branchial cartilages of the frog especially, "the about to be ossified or actually ossified part consisted of a beautiful tissue, exhibiting, *almost* like vegetable cells, hexagonal septa, on and in which little granules, (körnchen,) of a rounded form, and about 0·000152 of a Paris inch in diameter, were observed;"* whilst soon after the cellular structure of the dorsal cord was described by Müller, yet as Valentin admits, "Schwann gave undoubted completeness to these analogies when he showed that the gelatinous primordial mass of the tissues was composed of cells, that the granules or bodies embedded in it are nuclei, and that these often exhibit laws of evolution of the same kind as the cells."

It is generally held that cartilage, either permanent or ossescent, is the same identical structure; and Miescher says, "that there is not the least difference between them."† This observation can, however, be

* See Miescher, *loc. cit.* p. 5.
† See *Mém. de l'Acad. Roy. de Paris*, 1748, p. 385.
‡ *Ib.* p. 26.

* See Valentin, *Handbuch der Entwickelungsgeschichte*, p. 209.
† See Miescher, *loc. cit.* p. 15.

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Zoology. scarcely considered correct, for the costal cartilages, as well as those of the larynx, from whence he derives this opinion, are very commonly, the former especially, more or less ossified in adult beasts, and in birds and reptiles always. It will also be hereafter shown that the Purkinjean corpuscules are of different form in permanent from that which they present in ossescent cartilage, at least so soon as ossification commences.

"The fibrous matter in the blood and in the lymph, endowed with vital power, and fitted for building up the body, (lebenskräftige und bildungsfähige,) dissolved in the serum, forms," says Gerber, "the formative matter, *blastema*, which, by the primary and secondary organic processes, is capable of assuming all possible forms of animal elements. This fibrous matter coagulates when at rest, under all circumstances not affecting its decomposition, into a distinct hyaline mass, which under depression of vital energy, or in death, or when removed from the living body, resolves itself into granules, or forms a connected mass of granules. Thus far has the formal metamorphosis of the plastic fibrous matter two forms in common with other coagulating substances, viz., the formation of granules, and of a hyaline substance." He then proceeds to point out the different characters which distinguish the plastic matter of the blood, showing that, whilst albumen, either within or without the body, can resolve itself into granules, and is capable of no higher organization, the plastic matter of the blood "forms a true hyaline substance, which envelopes the blood corpuscules as that of cartilage does its corpuscules, and if it coagulate in connection with the interior of living bodies, in like manner exhibits a higher organic process by the formation of compound corpuscules, which either float freely in fluid as in the blood, or are scattered about as isolated corpuscules in the hyaline substance, or are at once arranged in different ways, attaining their ultimate arrangement, or merely exhibit transitional forms of more highly organized forms, which in the perfecting of their ultimate development are entirely lost. These corpuscules form the primary type of the higher formation of animal and vegetable bodies; they are at the same time the general organic chrystalline forms of the living plastic fluids. The vegetable corpuscules have been called by Robert Brown *areolæ* or *nuclei*, and by Schleiden *cytoblasts*; and if it be allowable, on account of their identity, to confer this title on the animal cell-nuclei also, I would call them *encased nuclei* (schachtelkerne.)"* Hence he divides the solid precipitates from animal fluids into two classes, the *Aplastic*, incapable of further organization, and the *Cytoblastic*, possessing in itself the germ of a higher development.

Before proceeding further, it will be convenient to give some account of Schwann's theory of the development of all the tissues from cells, or, more properly speaking, from germs or nucleoles, of which the cells are merely the investments.†

The *Cytoblastema* of Schwann is the structureless substance which, from its transparency, Gerber calls the "hyaline substance of the blastema," surrounding or embedding all cells, as their interstitial or intercellular substance contained also within their cavities, and being also the substance in which and from which the germs or cytoblasts are developed. It varies in quantity, is sometimes scarcely distinguishable between the cells, at other times separates them widely. Its consistence is very different: thus in the blood, as the *liquor sanguinis*, it is fluid, whilst in cartilage it is tough and unyielding. In cartilage it is converted into gluten by boiling, which is not the case with blood. When surrounding the cells it appears to be an homogeneous substance, but is rendered minutely granular by some chemical change; for instance, in cellular tissue and in the cells of the shaft of feathers. Its quantity is proportioned to the development of the cells, but in the cartilage rather in proportion to the growth of the tissue; and it obtains its fresh nutriment either from the blood-vessels, which, when they exist, pervade the substance and deposit it in every part, but if not existing in the tissue itself, from the neighbouring organized part with which it is in contact.

The *Cell-Nucleus* or *Cytoblast* has a very characteristic form, being either a round or oval, spherical, or flattened corpuscule; its mean size in the greater number of animal cells is about 0·0020 to 0·0030 of a line, but some are larger and others smaller. It is granular, dusky, and often somewhat yellowish, but sometimes is pellucid and smooth. It is either solid, consisting of a mass of more or less minute granules, or it is hollow, and indeed most of the animal nuclei exhibit a more or less distinct indication of their hollowness, their periphery being somewhat darker and thicker. In these hollow nuclei both their membrane and contents can be perceived: the former is smooth, structureless, and not of determinate thickness; the latter is very minutely granular or pellucid, or it may subsequently produce within the hollow nucleus large corpuscules.

The *Nucleoli* (kernkörperchen) discovered by Schwann are usually one or two, more rarely three or four little dusky corpuscules, varying in size from a scarcely visible point to that of Wagner's germinal spot or nucleus, but in some cell-nuclei they are not distinguishable. They are situated excentrically on the round solid nucleus, but in the nucleus, which is hollow, they are seen distinctly upon its inner wall. Schwann thinks it difficult to ascertain their true character, and that possibly in different nuclei they may vary considerably; but they are easily distinguished from the corpuscules, which at a later period are generated in the nuclei, inasmuch as they are really produced before the nucleus itself which forms around them, thus corresponding to the formation of the vegetable nucleus around its nucleolus as described by Schleiden. Of the production of the animal nucleus Schwann gives the following account:—

"At first is observed a little round corpuscule surrounded with minutely granular substance, whilst the rest of the cytoblastema is homogeneous. This granular matter gradually subsides externally; at a subsequent period it becomes very distinctly defined, and assumes the form of a cell-nucleus, which continues growing for some time. At the beginning it seems to be solid, and many nuclei remain in this state; in others, on the contrary, the most external parts of the nucleus are dusky, and not unfrequently at last appear to be a distinct membrane, so that the nucleus is then hollow. The formative process of the nucleus therefore may be thus described: a nucleolus is first produced, around which is usually deposited a layer of minutely granular substance, but without any well-defined external boundary. Between the existing molecules of this layer additional molecules are deposited, and at a certain distance from

* See Gerber, *Handbuch der Allgemeinen Anatomie*, p. 16.

† See his *Mikroskopische Untersuchungen über der Uebereinstimmung in der Struktur und dem Wachsthum der Thiere und Pflanzen*, p. 200.



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Zoology. the nucleolus the layer becomes defined, and thus is produced a more or less well-defined nucleus. If this deposit occur throughout the entire thickness of the layer, the nucleus remains solid, but if only on the outer part of the layer, it becomes much thickened, hardens into a membrane, and thus a hollow nucleus is produced. That the layer is usually much thickened exteriorly is easily explained, because the nutritive substance is added to externally, and is thus concentrated on the outer part of the layer. If there be now an intermission in the deposit of the molecules, longer continued between those molecules on the surface than between those which form the thickness of the membrane, the latter must increase more in extent than thickness, therefore between it and the nucleolus there is always a large interspace, in consequence of which the nucleolus remains adherent on one side of the inner surface of the membrane."* No decided observations have been made as to the origin of nucleoli with two or more nucleoli, but it can be easily imagined that two nucleoli may be so close together that the molecules deposited around them may become confluent before the layers are defined, and therefore, by further depositions, but a single layer is produced, and consequently two nucleoli are contained in one nucleus.

The *Nucleor-cell* is next produced by the nucleus depositing on its exterior a layer of substance different from the surrounding cytoblastema, at first without any definite limits, but subsequently, by the continued laying on of the new molecules, an external boundary is produced, which varies in thickness, and is sometimes homogeneous, sometimes granular, but more commonly the latter. No distinction between cell-cavity and cell-wall is yet discernible, but as the deposition continues, if the layer be thin, it is entirely consolidated; if, however, it be thick, only its external surface is gradually consolidated into a membrane. In many cells, however, no distinct membrane is developed, they appear to be solid throughout, and their outer surface only seems rather more solid. The cell-membrane now begins to expand by the deposition of new molecules between those already existing, thus effecting a growth by intussusception, and separates itself from the nucleus, the interspace between the two being filled at the same time with fluid, whilst the nucleus still remains during this extension attached to one point on the inner surface of the membrane.

When the cell has been thus produced, the nucleus either rests solid, as in the early stage of its development, or grows, and becomes vesicular, its granular contents disappearing and becoming instead pellucid; this growth however is always less active than that of the cell, and consequently the cavity of the latter is relatively larger than the nucleus. But if the growth of the cell be impeded by the proximity of neighbouring cells, the nucleus, as its growth continues, will occupy the greater part of the cavity; this however is of rare occurrence.

The construction of the cells, their composition of single or manifold layers, and the growth of these layers by intussusception, is throughout the same; but when once formed, they present differences in the several tissues, and hence are divided by Schwann into two classes, viz., that in which the individuality of the original cell is permanent, and that in which it is more or less lost by confluence or by division. 1. The permanent cells are either distinguished from each other on chemical grounds; thus the cell-membrane of the blood-corpuscules is dissolved by acetic acid, which those of cartilage are not; or on the mode in which the cell-membrane grows, that is, according to the regular or irregular deposit of new molecules on all its parts. In the former case, the form of the cell remains the same, whether its dimensions be increased by the extension of its cell-membrane, or whether the latter is only thickened; most commonly both processes go on together, but the extension is greatest. In the latter case, where the deposit is irregular, the form of the cell is much altered, its original globular shape may become polyhedric, or it may flatten itself to a round, oval, or angular plate, or it may extend itself in one or two directions, and form a fibre which may become flat and indented on one side, or it may spread into fibres in various directions, and thus assume a star-like form. The ground of this irregular deposition of the new molecules Schwann considers in several instances to depend on external causes: thus if one side of a cell be in contact with a large quantity of nutritious matter, it grows more quickly here than elsewhere, although the power effecting the growth of the cell is equally distributed throughout it. 2. The loss of individuality of the cells depends either on the confluence of their membrane with the intercellular substance or with the walls of adjoining cells, as occurs in some cartilages, the cell boundaries gradually becoming more and more indistinct till the consolidation is perfected. Or the cell may be divided, an indentation of the cell-membrane into its cavity taking place and continuing till the cell is divided into two, held together by a narrow neck which is absorbed: this occurs in the formation of many fibres, but the process is more complicated, although such is the actual mode of division; or, finally, the original cell is lost by coalescing with many others to form a secondary cell, as in the composition of muscle, in which several primary cells arranged in rows flow together and form one cylinder, on the inner surface of which however, the nuclei of the original cells are still contained.

Such then is a brief account of Schwann's discovery of the primary nucleor and cellular structure of animal tissues; and his description of the structure and development of cartilage, at present more especially under consideration, which he drew from examination of the branchial cartilages of the red-eye, *cyprinus erythropthalmus*, Lin., and those of the brown toad, *bufo fuscus*, Roes, is now very shortly to be sketched.*

The general structure of cartilage is every where essentially the same, consisting of elementary cells, with their nucleoli or cytoblasts, which are embedded in an interstitial substance, the cytoblastema, by which the nucleoles were primarily developed, and in which, as the cartilage grows, they continue to appear and become enveloped in their nucleus and cell. This interstitial substance is firmer in cartilaginous than in any other tissue, and is spoken of as the *proper cartilage-substance*; it is also more considerable in quantity, but in this respect varies in different animals. The cells are very small, polyhedric, with rounded angles, and closely approximated, with distinct but very thin walls, increasing however in thickness as they are matured. Their contents are transparent, and within each is a little round, pale, granular nucleus, sometimes two. If two cells be in contact, the walls of both are compressed into a seemingly single line, but at other times, when the intervening substance is in larger quantity, they are

* See Schwann, *loc. cit.* p. 207.

* See Schwann, *loc. cit.* p. 17, *et infra*.

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Zoology. separated by it, and the cell-wall or membrane appears as a comparatively thick ring, of which the periphery is more or less distinct. The intervening substance, which is homogeneous, assumes the form of the space left between the cells, and is therefore triangular, quadrangular, or multangular, as may be. At the margin of the cartilage this interstitial substance or cytohlastema not only surrounds the cells, which are as it were imbedded in it, but stretches out beyond them, and in it new cells are developed, both at the margin and also wherever it intervenes between the cells which were first produced by it. This evolution, however, is never on the surface, but always within the substance itself, and the several changes from the simple nucleus, which is of smaller size than the nucleus of the mature cell, the nucleus closely surrounded with its cell wall, up to the perfectly developed cell, may be seen in it. The cells are at first minutely granular and less transparent than they subsequently become; the nucleus grows in proportion with them, and when they have attained their full size their wall or membrane becomes distinct. Sometimes two or more cells are developed in the same interspace, the intervening substance and the previously formed cells are then thrust outwards; these cells form a group, separated from each other only by their own thin walls, but from those surrounding them by a much thicker partition. In proportion to the development of the cartilage the walls of the cells thicken, and their cavities diminish, the nucleus generally disappears; and as the hollows of the cells are filled with the same matter which forms the intervening or proper cartilage-substance, the only indications of the pre-existence of cavities are numerous little rings which are now seen in the homogeneous mass of cartilage, which, with their contained transparent substance, are the *Purkinjean* or *cartilage-corpuscules*. In the thickening of the walls of the cells, by which their cavity is gradually contracted and at last entirely destroyed, no signs of a laminar deposition can be observed; this forms one of the characteristics of an animal cell, as in the vegetable cell there is most commonly such laminar arrangement, although even in plants also occasionally the cell-walls thicken without any deposit in layers, as in the case of the pollen sac of *formium tenax*, according to Schleiden. In the tadpole of the frog the cells or cartilage-corpuscules are larger than in fishes, and their interspaces thicker. Sometimes two or four cells are generated in a parent-cell, the thicker wall of which separates them more perfectly from those contiguous, whilst from each other they are parted only by a thin wall; this may depend either upon the walls of the mother-cell having been originally thicker, or upon a disposition of the secondary cells to thicken their walls at those parts where not in contact with each other. Of this one-sided thickening an analogy exists in the formation of the cuticle of plants. The periphery of each cell, however, still remains distinct, proving that the cells are not mere cavities in the cartilage-substance. This is also of further importance, inasmuch as in many parts of these thickened walls there is often an appearance of parallel lines, which might lead to the presumption of a laminar deposition on the inside of the cell-walls, but is easily explained by bearing in mind that, in the contact of two parent-cells, there is in each half two walls, viz., that of the parent and that of the secondary cell, so that each space between the two groups really consists of the four walls of as many cells. The cartilage-corpuscules are thus in general either the proper cartilage-cells themselves, or merely their cavities; the former, if the walls be not thickened or consolidated with the intercellular substance, the latter, if such thickening and consolidation of the cell-walls takes place. They contain, in either case, at first their proper germ or cytoblast, which is either subsequently absorbed, or even, in the cartilage of bone, remains as a rudiment after ossification has taken place, so that after the abstraction of the lime by acid no trace of it is found. The cartilage-corpuscules are either distributed regularly throughout the cartilage or in masses of two or four, and are more numerous the younger the cartilage is; but whether diminution of them occurs as the proper cartilage-substance increases, is not determined.

### Of the Osseous Tissue.

*Tela Ossea*, Lat.; *das Knockengewebe*, Germ.; *le Tissu Osseux*, Fr.

The hardness, solidity, and inflexibility of this tissue, as seen in the composition of bone, are of great importance in vertebrate animals, for on bone not merely depends the general form of the body to which it furnishes a framework, upon which the soft parts are expanded and attached; but the various cavities in which important organs are contained and protected, and the columns and levers by which the body is sustained and moved are all composed of this tissue, arranged in various form and density as the necessities of the being require. The shapes under which bones appear are of four kinds, viz.: 1. *Tubular, cylindrical*, or *long* bones, in which the form is that of a pipe or cylinder, and the longitudinal dimensions the greatest, as in the bones of the arm, leg, &c. 2. *Broad* or *flat* bones, which are widely expanded and have little thickness, as most of the skull and face bones, as also those of the pelvis, &c. 3. *Thick* bones, of various shape, in which the diameters do not materially exceed each other, as in the bones of the wrist and instep, of the spinal column, &c.; and 4. *Mixed* bones, which participate in the characters of the former classes, without being referable to either, as the ribs, &c. The surfaces of all bones exhibit more or less irregularity, in shape of hollows and projections, to the latter of which are assigned the names *processes* or *apophyses*, and both are specially designated by peculiar terms, according to their form, use, &c.; thus the acetabular cavity of the hip-bone, the articular cavity of the temporal bone, the styloid process of the same bone, and the acromial process of the blade-bone. All the bones are connected together, the flat bones by their edges, the long bones by their extremities, the thick and mixed bones by their entire surfaces, or by parts of them. In those connections where great motion exists, as in the elbow, knee joint, &c., the surfaces are extremely smooth and correspond to each other: such are called articular or joint surfaces, and each is overspread with cartilage to facilitate their movements. In other joints, where the required motion does not exceed a slight yielding to prevent concussion, the junction is either by cartilage, upon each side of which the connected bones are fixed, or a peculiar kind of fibrous tissue, intermingled or not with cartilage, is interposed.

The external surface of bone is more or less smooth and hard, but if closely examined, it presents an immense number of delicate apertures, through which the vessels of the periosteum (a membrane investing bone) pass into its substance. These apertures,



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although very minute in the middle or body of long bones and in flat bones, whence their greater density, at the extremities of the former degenerate into little grooves, which run longitudinally for a short distance, so that the vessels there enter the bone obliquely. At these parts of long bones, and also on the surface of thick bones, the apertures are most numerous. If a bone be sawn through longitudinally, the general disposition of the osseous tissue is found to be two-fold, the whole exterior consisting of a close compact texture, which in most, except the tubular bones, is of nearly equal thickness, and that not great, over the whole surface. In tubular bones, however, the *cortical* or *compact substance*, as this is called, is remarkably thick in the centre or *diaphysis* of the bone, and gradually attenuates towards the extremities or *epiphyses*, where its thickness does not generally exceed that of other bones. The space within the cortical substance is filled up with cells of various size communicating with each other, which form the *cellular* or *spongy substance*, and in the flat, thick, and mixed bones, occupies the whole interior, and in the former is called the *diploe*. But in the tubular bones, it especially fills their extremities, where the cortical substance is very thin, and in proportion as the latter thickens, till it attains its greatest thickness in the middle, the cells gradually enlarge, diminish in number, their communications become more ample, so that a net-like appearance is first produced, which has been called *reticular substance*, and subsequently entirely disappears, leaving in the middle of the bone the *medullary cavity*, which is the most capacious, and gradually tapers away towards the extremities of each tubular bone.

Bone consists of two parts, an organized model, in which is deposited earthy matter to give the former solidity and strength. These components are readily shown, *first*, by maceration in dilute muriatic acid, which abstracting the earth leaves a soft flexible elastic body, exactly corresponding to the figure of the bone; or *secondly*, by calcination, which destroys all the organized part, and leaves only an earthy model, extremely inflexible and highly fragile, and when plunged in weak acid dissolves and leaves no residuum. Of the elements of these substances notice will be hereafter taken, but at present it is more convenient to consider the actual structure of bone in its adult or fully developed condition.

*Structure of Bone.*—Few animal structures have attracted more attention than bony tissue, and, as might be expected, it did not escape the observation of the indefatigable Malpighi. In his *Anatomia Plantarum*, he describes bone as consisting of filaments "not exactly parallel, which here and there give off little filamentous appendices, by which, being connected together, they form a net-work little differing in its nature from the *liber* of trees, the larger areas of which and the whole mass of fibres are filled with an exuded osseous juice: by successive growths new planes of fibres are produced, which being agglutinated to the pre-existing plates produce the proper bulk and density of the bone."*

Gagliardi,† on the contrary, maintains, that the external dense structure of bone consists of innumerable small scales and leaves, made up of nervous threads and a concrete juice-like gypsum; that these scales are connected together by little osseous pegs or keys of various form, and that they pass not merely from one to another, but penetrate through several leaves, which are perforated for that intent; whilst the spongy substance he describes as made up of differently formed plates, either running into each other, or connected by folds or little bones, the latter of which, flat, round, or branching, he considered not only as joining the plates, but also as keeping them apart at their proper distance.

"The real formation of the bones" excited the inquiries of the laborious Leeuwenhoek, who says, on examining "the solid part of an ox's thigh bone, I plainly saw it consisted of four different kinds of tubes, running lengthways in the bone, the least of which are so small, and lie so closely together, that they cannot easily be distinguished in a bone cut transversely; and even if the bone be cut with the sharpest knife, nothing is seen but the appearance of globules; if, however, the bone be split or cleft, some fragments will be broken off in which those small tubes will be perceived." The next kind of tubes, although some are four or six times so large as the former, are also not easily discoverable. These often however appear like dark spots, because their orifices are stopped up in cutting the bone. The third sort of tubes are larger than the last, and Leeuwenhoek says of them, "I have observed these tubes being disposed in such a manner, that I was well assured a circle of those tubes formed every new concretion or addition to the bone, almost in the same manner as I have laid it down in regard to the growth of timber, by the addition of a circle or ring of tubes, formed in the growth of the wood; and especially when I saw that in a small space from thence, another circle of tubes was to be seen." The fourth kind of tubes were still much larger, and also fewer in number. Besides these longitudinal tubes, he "often imagined he saw some tubes taking a contrary course, which seemed to proceed from the internal part, and terminate at the surface of the bone;" and he also thought they "were of two sizes; the least he imagined were analogous to the smallest of those tubes which lay lengthways in the bone. "The reason why I could not truly perceive," says he, "the tubes proceeding from the cavity to the circumference of the bone was I think this, that these tubes were far distant from each other; and indeed I thought that one tube lay among the longitudinal ones, as if an opening had been made there for it. And though I could not be quite certain as to my seeing these tubes, I do not doubt that there are a great number of them in the bone; and the rather, as I think it is to be noted, that the membrane covering the bone is chiefly formed out of these vessels, and that it is also supported by them."*

Our countryman Clopton Havers says, that "the particles of which the bone consists, when we consider how they form strings, seem to be of a long figure, and their position streight, so that one end lies towards one, and the other towards the other extremity of a bone in the sides of it. I say in the sides, because where the strings alter their course and run obliquely or transversely, as in the *cancelli* and small caverns of the bones, and at the extremities where they lie over and shut up the cavities, the position of these particles must

* See Malpighi, *Oper. omn.* p. 19.

† See his *Anatomes Ossium novis inventis illustratæ*

* See his *Anatomia seu interiora rerum ope Microscopica detecta*, p. 199.

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be different."* He further observes, that "the bony particles are in every series united at their extremities, and by this union they form threads or strings," of which "the course or tendency in the sides of a bone is as the position of the particles from one end towards the other, and wherever the laminæ which they make are contiguous, they are parallel, and so far streight as the figure of the bone will admit." Although some of the strings run to the very extremities of the bone, and others nearly as far, they "do not terminate definitely, but are continued, and run transversely and as it were arched; that the strings of one side of the bone proceed so as to meet and be united to those which are propagated from the opposite, and this at both extremities; that they are a continuation, though not of the figure, yet in the manner of a ring."† The one forming the external plate are of the full length of the bone, but all the others are shorter, and run off, so that, in proportion as this inversion of the plates takes place, "the side or wall of the bone grows gradually thinner towards the extremity, so that by that time we come to the end of it, we have not above a fifth or sixth part, and it may be less, remaining, to make the thickness of that part. Thus in the os femoris of a human skeleton, I have observed the thickness of the side before any of the strings ran off from it to be five times more than that of the head. So that if we suppose the side to consist of five and thirty plates, then has the head but seven, which lie contiguous to one another, and inclose the cavity." And he further remarks, "every one of these plates, excepting those which have their strings at any end running into fasciculi, could they be divided entire, would be like a tube imperforated at both ends."‡ Of the number of these plates Havers says, that in one ox bone, by the aid of the microscope, he counted sixteen, and then by computing the number of those, not so easily discernible, by the thickness of those he could distinctly make out, he reckoned three or four and thirty; in another he counted one and forty plates, and computed fourteen more, making a total of fifty-five plates; and in a piece of the human skull he counted sixteen or more plates. He first mentioned that "in the bones through and between the plates are formed *pores*, besides those which are made for the passage of the blood-vessels, which are of two sorts; some penetrate the laminæ, and are transverse, looking from the cavity to the external superficies of the bone. The second sort are formed between the plates, which are longitudinal and streight, tending from one end of the bone towards the other, and observing the course of the bony strings."§ The transverse pores, although existing in all, are more numerous in the inner than the outer plates, and they never "lie directly one under the other to form one continued passage from the cavity to the external plate," and even "in the same lamellæ they are disposed with a seeming irregularity, and scattered, not being digested into such an order as to form circles or exact series of pores;" by which circumstance they do not interfere with the solidity of the bone. The longitudinal pores formed between the plates are less easily observed, but he considers the use of both kinds is to convey the medulla which diffuses itself by the longitudinal pores, whilst "the transverse pores are subordinate to these, and rather designed for the passage of the marrow into them than for the immediate communication of it to the substance of the bone," as, the transverse pores of the first internal plate having no correspondent ones in the second, the marrow passes from them into the longitudinal pores there situated, and being carried along in them till it finds some transverse pores in the second plate, passes through them into the longitudinal pores between that and the third plate, and so on till it reaches the external plate.

Scarpa, in 1799, totally denied the fibrous character of bone, and says, "that which in bones is called *fibrous* is none else than a seeming and a fallacy; for the short lines, foolishly called *fibres*, are connected at very minute distances, and at very variable angles, by other very short tracks of the very same kind, which by their successive apposition easily impose on the careless observer, as if they were indeed filaments passing from the top to the bottom of the bone. However by aid of the best glasses, every one may easily perceive, that those tracks are *branching*; that they coalesce with those adjoining at more or less acute angles, and, interwoven with them in various and manifold ways, form a *sort of net-work* widely extended over the whole surface of the bones, be they cylindrical, or broad and flat." And a little further on he adds, "But not merely the external surface of bone, which falls under the observation of every one, but also the innermost part of the bony texture, I declare and assert to be *reticulate* or *cellular*."*

In 1816 Howship communicated to the public the result of his examinations† into the structure and œconomy of perfect or full grown bone, properly choosing for the purpose "the most heavy and compact portions of bone, (the solid sides of the cylindrical bones,) where it is found to be most distinct from the soft parts, in preference to the spongy and cancellated extremities." In every instance he found "numerous small canals of a circular figure passing in a longitudinal direction, but none of them empty; the larger canals thickly encrusted with an opaque, whitish-coloured matter, which, on examination with the point of a needle as it lay under the microscope, was found to have the consistence of spermaceti, while the smaller canals were apparently filled up with the same substance, the situation of the canal being distinguishable only by the brighter colour of its contents compared with the other parts of the surface of the bone."‡ According to his account the canals vary in diameter from 1-100 to 1-400, but their mean is 1-200 of an inch, and he says that they "have numerous lateral communications with the internal or medullary cavity, and also with the external surface of the cylinder." He considers that "all the canals in bone are destined to contain medullary secretions, and not merely to transmit vessels, as has been frequently asserted." His statements upon this point are however very confused, but it is evident that their contents are both medulla and vessels according to his view, for he subsequently says, "that he found, whatever was the size of the canal, the diameter of its vessels was in proportion, and bore a very small part in comparison with the medullary secretion with which the canal was filled." And further on,

* See his *Osteologia Nova, or some New Observations on the Bones*, p. 33, *et infra*.
† *Ibid.* p. 35, *et infra*.
‡ *Ibid.* p. 39, *et infra*.
§ *Ibid.* p. 43, *et infra*.

* See his *Dissertatio de Structura Ossium penitiori*, p. 5.
† See his *Microscopic Observations on the Structure of Bone* in *Med. Chir. Trans.* vol. vii. p. 387.
‡ *Ib.* p. 393. *et infra*.

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that "the very smallest, as well as the largest of the canals, appeared to him furnished with a membrane lining its cavity, which membrane conveys the vessels that deposit the medullary contents of these tubes, in the same way that the fine membranous capsules within the general medullary cavity furnish the marrow contained within the bone." The canals he found to be more spacious, and their communications more free, the nearer they were to the medullary cavity, but they uniformly became smaller as they approached the external surface, although perhaps the points of communication were not less numerous at the one part than the other. The plate attached to this paper gives a very good view of some longitudinal canals, with their transverse communications, in the compact part of the humerus, which are doubtless the two kinds of pores spoken of by Havers, whilst the longitudinal are probably the third and fourth kind of tubes seen by Leeuwenhoek and the transverse ones.

Beclard says, that after removing the earthy part from bone, it can be reduced into gelatine by boiling, but if macerated in water, "the compact substance which exhibits no apparent texture separates into plates connected by fibres; that the plates themselves, more tardily and with greater difficulty, divide into fibres, which, by more long continued maceration, swell and become areolar and soft like cellular or mucous tissue." Whilst, on the contrary, if this animal part be destroyed by subjecting a bone to the action of fire, "there remains a white substance preserving the bulk, form, and a considerable part of the weight of the bone; this hard but very fragile matter is an earthy salt which makes part of the osseous tissue." As to the composition of the osseous fibre, after just noticing the opinions held about it, and mentioning that of Mascagni, that it is formed of absorbent vessels filled with phosphate of lime, he says, "we are entirely ignorant what exact relations the earthy has to the organic substance of bone."*

Within the last few years these discrepant accounts of the structure of the compact part of bone seem, at least some of them, to have been explained, and, as is not unfrequently the case, the apparently very different descriptions have in some points been ascertained to be correct, so that it may be now presumed that the true structure is at last comprehended. For this we are indebted to the labours of Purkinje, Deutsch, and Miescher, and more especially to the latter.

Deutsch describes† the longitudinal canals, discovered by both Leeuwenhoek and Havers, as surrounded by concentric lamellæ; and that, as shown by Howship, they contain medulla. He discovered large concentric rings, which correspond with the periphery of the bone, passing between the longitudinal canals, and that these are perforated by very numerous little streaks, which he considers canals, and the apertures of which are triangular. Deutsch supposes that in these extremely minute canals, of which, till his account, no one was supposed to have had any idea, the lime or earthy part of the bone is deposited. But it may seem not improbable that they are really "the tubes taking a contrary course, which seemed to proceed from the internal part and terminate at the surface of the bone," which Leeuwenhoek often imagined he had seen. Purkinje discovered in the cartilage of bone a sort of isolated round corpuscules, which will be presently adverted to, much larger than the last mentioned tubes. They are supposed to be the globules mentioned by Leeuwenhoek. Their recent discovery by Retzius in tooth-substance, together with the co-existence of tubes, as already mentioned, is highly interesting as showing the close connection if not identity of the proper tooth and bone substance.

As it appears from the statement of Miescher, that all bones, of whatever form they be, can be shown to consist of concentric plates, canalicules, and corpuscules, it remains to consider them as disposed in the formation of bone.

*Of the Concentric Plates.*—The walls or compact substance of bone is principally made up of thin plates of cartilage, in which the calcareous matter giving it solidity and strength is deposited. These plates are of a cylindrical form, concentrically arranged, being received within each other like the tubes of a closed telescope. The outer are the longer and the inner the shorter, hence the long wall is thickest in the middle, as observed by Havers. The outer cylinders are much more closely approximated than the inner, which gradually become more distant as they approach the medullary cavity, for a reason presently to be mentioned, and hence the outer part of the bony crust is much the most dense. In flat and mixed bones the plates are ranged concentrically within each other like a nest of boxes. This laminar disposition may easily be observed by quickly burning a bone, when coarse flakes fly off; but, according to Deutsch's experiments, by macerating for a long time in water, bone which has been previously treated with muriatic acid, very minute plates can be separated without difficulty, the thickness of each of which, according to Miescher, is only 1-4440 of an English inch. These cylindrical plates in the narrow middle of tubular bones form the whole thickness of the bony wall, but in passing towards the larger extremities they are gradually separated by interposed fibres, which increase in number till the plates seem to be entirely lost, excepting those which form the very thin crust or external surface of these parts. Miescher however says, that with care the plates may be followed even through the fibres; whilst, in reference to those parts in which the plates are closely conjoined, he says, "I have also observed slender roundish fibres, running longitudinally, of a dusky colour, and pretty solid, which here and there penetrated the plates, and are doubtless both 'the little keys' described by Gagliardi, and 'the fibres' observed by Medici. The plates themselves could also be divided by the aid of fine needles into many very delicate leaflets, and under the microscope appeared to be made up of ten or twelve such."* The texture of the most simple plates, and how they are connected with each other, Miescher says he cannot satisfactorily make out; but he is satisfied they are not made up of fibrils either parallel or complicated into a net-work. It would seem most probable, however, that they are the remains of the original cartilaginous nidus, into which earthy matter is deposited, and that the peculiar laminar appearance merely depends upon the partitioning of the cartilage by the canalicules by which it is pierced. Deutsch says, that innumerable transverse canals are interposed between the plates, to the thickness of which they correspond in length, and supposes that their purpose is both to join the plates

* See his *Élémens d'Anatomie Générale*, p. 488.

† See his Inaug. Dissert. *De Penitiori Structura Ossium.*

* See Miescher, *De Inflammatione Ossium eorumque Anatome Generale*, p. 37.

together, and to contain the salt of lime. He observed them in a transverse section of softened bone as delicate short threads passing in a radiated direction from one concentric layer to another, and on examining the finest layers he found little points close set, triangular, with distinct boundaries, which he supposed were apertures corresponding to the little lines. Miescher also noticed the same appearance, and speaks of them "as little opaque points existing in the middle of the plates, but not occupying their entire thickness, so that radii seem to run from the centre of the canalicules to the periphery of the area." What their use is he cannot determine, having "observed them in leaflets not deprived of their salts, no less than in those from which the cartilaginous part had been removed by boiling caustic potash; they are found also in primitive cartilage, pass from it into the place of ossification, assume a kind of granular appearance and become more visible; it cannot therefore be doubted that they exist as well before as after ossification, but whether they be corpuscules or cells, or hollow cells before and solid after ossification, more expert microscopic observers must determine: I have never, however, succeeded in discovering apertures in the thinnest leaflet."

*Of the Canalicules.*—These are the third and fourth tubes of Leeuwenhoek, the longitudinal and transverse pores of Havers, and the canals of Howship. In the long bones the canalicules pass from end to end; in the flat bones from the centres to the margins of both tables of the compact substance, and in the mixed bones from the points of ossification. They have a cylindrical form, nd are smallest at the external surface of the bone, but gradually increase towards the medullary cavity, so as to become three or four times so large as the former, and occasionally form cells either singly or by the confluence of several small ones, and which communicate with the medullary cavity. They are found as well in the spongy as in the compact substance of the bone, opening into the former by trumpet-like mouths, and upon the latter by minute canals, which penetrate obliquely through the concentric plates. Deutsch discovered, in examining the transverse section of a bone beneath the microscope, that these canalicules are surrounded with concentric tubes, Miescher says, fourteen or fifteen. The diameter of the tubes, according to Howship, in calcined bones, varies from 1-100 to 1-400 of an inch; but in bone deprived of its earth by acid, Miescher found the diameter varies between 1-320 and 1-328 of an inch. The latter observer also notices that these canalicules are connected by transverse passages, and shows in a beautiful plate, that where such passages are found, the concentric tubes, instead of being circular, are drawn out into a more or less oval form so as to surround them also. Miescher agrees with Howship, that the canalicules contain marrow, or something like it, the adipose vesicles being tolerably distinct in the larger cells; but in the smaller, where is less space, no vesicles are found, but in their stead a yellowish pellucid substance. He succeeded also in injecting their vessels both from within and without, being more successful than Howship, as he not merely saw the vessel entering and nearly filling the canalicule, but as it passed deeper, diminishing twice or thrice in bulk, and surrounded by the matter filling up the remaining space.* In the interior of the bone, besides the larger vessels running close to the crust, he observed many smaller ones coalescing to form a net-work, and thence distributed in the marrow. The similarity of conformation between the canalicules, the cells of the spongy substance, and the medullary canals, is so great, that Miescher observes, "the spongy substance is nothing else than enlarged canalicules; that the medullary canal itself, as to its formation and actuality, is merely an union of such enlarged canalicules, and that the canalicules surrounded with concentric plates, and containing marrow produced by numerous vessels, are the elements or primary form of the osseous tissue perfected by growth."*

*Of the Corpuscules.*—These are the isolated round corpuscules of Purkinje, the dark spots of the orifices of Leeuwenhoek's second kind of tubes. They exist in every part of a very osseous tissue, and, after the earthy matter has been abstracted by acid, appear like very minute dusky spots, having a transparent centre bounded by a distinct opaque line. Upon a dark surface they appear white, but when examined with a transmitted light are opaque, and the surrounding substance is transparent. Miescher says their form is ovate; more or less compressed, and terminating in a point at either end, and with a high power their periphery appears dentated, and resembling a radiated crown: their size varies, the long diameter from 0·0048 to 0·0072 of a line, and the short from 0·0017 to 0·0030.† When observed between two concentric plates they are found to be placed obliquely to their course; but on a single plate they appear as scattered roundish spots. Müller states, that in examining very thin plates of bone, from which the earth had not been removed, numerous lines, which he believes to be tubes, pass from the flattened surface of the corpuscules, through the lamellæ of the pellucid substance, and unite with similar lines or tubes from other corpuscules: and he says their diameter varies from 1-5000th to 1-3333rd of a line. Neither their white colour nor opacity is altered by heat or boiling in æther or alcohol. Miescher says that, after destroying the cartilaginous part of a thin plate of bone by immersion in caustic potash for some time, the remaining milk-white and though very fragile plate of bone still retaining its form, was entirely dissolved without leaving any residue in dilute muriatic acid, hence he considers the remaining parts were saline. Müller says, that when a thin plate of recent bone is immersed in muriatic acid, the corpuscules and tubes become transparent like the intervening substance; that in mollities ossium the corpuscules and their tubules are no longer to be seen; whilst in fossil bones and those deprived of their animal part by boiling in carbonate of potash, they are still visible; hence he infers that they contain calcareous salts either in their interior or on their surface; but he does not state that all the earthy part of bone is contained in them. With regard to the corpuscules and their tubules it may also be here noted that Mayer considers the former merely as particles of the blood impregnated with calcareous matter, and that the appearance of lines depends on the separation of the granules of the osseous substance during drying. Miescher mentions the following very curious circumstance in reference to the corpuscules: "if a bone, half deprived of its earthy matter, be boiled for an hour or an hour and a half, the cartilaginous structure disap-

* See Miescher, *loc. cit.* p. 39.

* *Ib.* p. 40. † *Ib.* p. 40.

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pears, and it is converted into a glutinous or gelatinous substance, but without dissolution. Where it touches the unchanged part of the bone, it presents the appearance of being sprinkled with whitish powder, and under the microscope exhibits many ovate or roundish opaque corpuscules in a transparent matter; these corpuscules have no chrystalline appearance, therefore cannot be a precipitation from a solution of, or saturated with calcareous salts; nor can they be the residue of corroded bone: as they all have the same form and size without any corrosion of their edges. On the addition of dilute muriatic acid they become pellucid; but distinct dusky spots remain, and there is no ebullition. These corpuscules in form, size, and entire external appearance are similar to those already spoken of; and from the above observations it may be collected that the lime contained in them is differently connected with acids than in other parts; that they do not contain carbonic acid unless it had been previously disengaged, is proved by the absence of effervescence in this solution."*

*Of the Vessels of Bone.*—The arteries which enter bones belong in part to the bone itself, and in part to the marrow therein contained. The latter, which from their size are most obvious, have been very improperly called the nutritious arteries of the bone, for in reality they only pass through the crust, accompanied with corresponding veins, by one or more large apertures into the marrow, where they terminate in a very delicate net-work upon the thin vesicles in which that substance is contained.

The proper arteries of bone are extremely minute, and penetrate into its crust, unaccompanied by veins, through exceedingly numerous, narrow canals, as small as hairs, and at acute angles with the surface; those which specially belong to the spongy substance penetrate by apertures of various sizes, according to Weber, where the bone is most spongy. As already stated, in speaking of the canaliculi, the proper arteries enter singly into each canal, and there divide into several small branches. According to Deutsch, ramifications of very delicate lines are seen both in longitudinal and transverse sections of bone, which he supposes are the most minute branches of blood-vessels.† These lines, however, Miescher was never able to find; but he says that, having separated single plates, "minute round apertures were seen of much smaller size than the canaliculi, and quite distinct from them, from which spread out in a branching manner lines more transparent and clearer, so that they might indicate the position of thinner plates; but whether these were connected with the capillary net-work of the bony tissue, which is very probable, he could not determine."‡

As to the veins of bones, it is now generally presumed, from the analogy of the medullary vessels, that they always accompany the arteries. Breschet§ has sought after them with great care; and in the skull bones, after removing the hard external crust, he describes distinct canals of tolerable size, formed of a thin bone-plate, and lined with a very delicate membrane, which can be raised with the point of the knife, and when opened exhibits numerous little semilunar or valvular folds. These venous canals communicate by numerous apertures with the cells of the diploe, but differ in their ramification and course, some passing outwards to the neighbouring veins, and some inwards, either to the veins, or to the sinuses of the dura mater. In the bones of the spine, he found at the back of their body, the aperture of a large canal, which very shortly divided into two branches; these forming arches, reunited, and formed a ring, whence five vessels were given off, connected with the medullary cells, and also with the external veins. In what way the blood is returned from the canalicules of the middle of long bones, whether it passes into the medullary or periosteal veins, is not known.

It is most probable that bones are furnished freely with Absorbent Vessels, for it cannot be understood in what way not only the ordinary process of enlarging the cavity of the bone, which is known to take place during growth, can be effected without them, but no less in what manner, under morbid action, cavities are made in the shell of the bone, as in case of abscess, or portions thrown off, as in exfoliation; but they have not yet been satisfactorily made out, although Van Heekeren states that he has seen them in the hollow bones of the stork.

Nerves also are seen entering by minute branches into the crust of bone, but of their further distribution nothing is known.

### *Of the Periosteum.*

The entire surface of all bones, excepting their articular surfaces, which are overspread with cartilage, are covered with a membrane, generally called *Periosteum*, but on the large bones of the skull specially, *Pericranium*. It consists of fibrous tissue, connected with cellular membrane, and containing vessels both sanguineous and absorbent, and has doubtless nerves, although, when in a healthy condition, it is scarcely sensible. It is closely connected to all parts of a bone, but specially where it is rough, and its connection is, at least in the tubular bones, more intimate in old bones than in young; on the flat bones, however, the connection is closest in young bones. It does not cover the articular surfaces, but having reached their edge turns off, and forms the outermost layer of the capsule of the joint. In those situations, however, where two bones are connected by cartilage without any true joint, as in the union of the ribs with the breast-bone, the periosteum passes directly and closely over the intervening cartilage. By its external surface it is connected with the neighbouring parts, and is often conjoined with ligaments and tendons, at their attachment to bones, so intimately, that they cannot be distinguished from each other. Upon the middle of bones its fibrous bundles sometimes run parallel, sometimes decussate, and form oblong meshes, which become more distinct towards the extremities. It is very tough, but more so in some than other parts: thus the dura mater, or internal periosteum of the skull, is extremely tough and distinct, its fibres being numerous and very closely interwoven; whilst, on the contrary, the periosteum lining the cavities of the skull and face bones is exceedingly thin and delicate. Its surfaces are generally both very flocculent, especially that next the bone, which results not only from little processes being sent into its clefts, but also, and principally, from the numerous delicate vessels passing from it into the shell of the bone.

The *Use* of the periosteum appears to be two-fold,

* See Miescher, p. 42.
† See Deutsch, p. 15.
‡ See Miescher, p. 58.
§ See his *Recherches Anatomiques sur le Système Veineux.*

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*first*, to form a bed in which the vessels may conveniently divide and subdivide, so as to reduce them to sufficient delicacy for entering the minute apertures in the crust of bone; and *secondly*, to render bone less frangible, by providing it with an almost unyielding covering: and so tough is it, that not unfrequently fractures of the skull take place without rupture of this membrane, and now and then the same circumstance occurs even in tubular bones.

### *Of the Medullary Membrane.*

The interior of all bones, which are filled with spongy substance, contain more or less fat, of a very oily nature, and commonly known as *marrow*, which is deposited in a very delicate cellular tissue, properly called the *medullary* membrane, but very improperly *internal periosteum*, as which it is sometimes described, for it is entirely devoid of any character of fibrous tissue, and, as Miescher states, if closely observed, does not line the bony cavities, but is only adherent to their walls, or, as it might be more correctly expressed, is only contained within them, so that by gently drawing, the whole mass of the membrane and its contents may be removed without injury, except at those points where processes of it pass into the canals of the crust. The medullary membrane is disposed in cells, which contain the marrow vesicles. These are round or ovate, yellowish, transparent, and without regular arrangement, and if broken an oily fluid escapes. Their size is smaller than that of the other fat vesicles of the body; according to Soemmering their diameter is from [illegible] to [illegible] of an inch, but Miescher makes it greater, viz. from [illegible] to [illegible]. It is more fluid in the diploe of the skull, and having more blood, is deeper coloured than in other parts. In the canalicules of the crust the vesicles do not seem to exist, but the material thrown out in them corresponds entirely with marrow, and Miescher says that when the walls of a bone are expanded by disease vesicles are then found. In young embryons, the marrow, according to the observations of Soemmering and Bichat, is deficient, and in its place there is a jelly-like substance, which burns with much greater difficulty. Isenflamm also states that, even in a child of a year old, there is still only a red jelly, traversed by numerous blood-vessels. Subsequently the interspaces of the spongy part of the bone increase, and with them corresponds the development of the marrow, which increases in quantity as life advances, so that in the bones as well as in other internal parts, the fat is stored up in age, whilst it is withdrawn comparatively from the surface of the body.

*Chemical Composition.*—Bone consists of an animal part now proved to be actual cartilage, and a mineral part: the former is obtained by steeping a bone for some time in dilute muriatic acid, which abstracts the earth, the latter by careful calcination, or by boiling in caustic potash, which destroys the cartilage. The proportions which these parts bear to each other, according to Schreger, are—

| | In a Child. | In an Adult. | In an old Person. |
|---|---|---|---|
| Animal matter | 47·20 | 20·18 | 12·2 |
| Earthy matter | 48·48 | 74 84 | 84·1 |
| | 95·68 | 95·02 | 96·3 |

The general analysis of bone, according to Berzelius, is in 100 parts:

| | | In Man. | In the Ox. |
|---|---|---|---|
| Cartilage soluble in water | 32·17 | 33·30 | 33·30 |
| Vessels . . . | 1·13 | | |
| Phosphate of lime with a little fluate of lime . . | | 53·04 | 57·35 |
| Carbonate of lime . . | | 11.30 | 3·85 |
| Phosphate of magnesia . | | 1.16 | 2·05 |
| Phosphate of magnesia with some chlorate of the same . | | 1·20 | 3·45 |
| | | 100· | 100· |

How the earthy matter is connected with the animal part of bone is not understood, but it has a powerful effect in preventing putrefaction and destruction of that tissue. Bichat states that a collar-bone, which had been exposed for ten years to wind and rain, had, after abstracting its earth, nearly the same quantity of animal matter as a fresh bone. Monro (tertius) examined the bones of King Robert the First, of Scotland, which had been kept in a leaden coffin, and although he died in 1350, the thin bones of the orbit were perfect, and only some small bones of the feet deficient. Hatchett found the animal proportions unchanged in a humerus taken from an Anglo-Saxon tomb. Miescher mentions that an Egyptian mummy of 3000 years since, retained all its cartilage. Cuvier states that the fossil bears' bones from the Gailenreuth caverns contained plenty of cartilage, and had suffered little damage; and Gimbernat prepared soup from the fossil bones of a gigantic elephant.* Miescher observes, "that the connection of the earthy with the animal part of bone must be considered organico-chemical, till anatomical observation proves the contrary, or chemistry points out some novel and certain way by which the condition of mineral conjoined to organic parts may be defined. Doubtless were they, as secreted from the blood, deposited in obedience to chemical laws, it might be expected they would chrystallize; but what is noticed in many concretions cannot be discovered in bone with the most powerful lenses. Moreover cartilage abstracted from bone when moistened with a solution of the extracted salts and dried ought to be reconverted into bone, which is attempted in vain, which must, however, necessarily be visible in the conversion of cartilage into bone, but which I never saw, although I directed my attention most closely to the subject; but as whilst cartilage is gradually ossified, we see its texture gradually change, that metamorphosis must be entirely a vital process."†

### *Of the Development and Growth of Bone.*

The development of the Osseous Tissue has been matter of great dispute among anatomists. Its cartilaginous origin, however, appears to have been first asserted by Veslingius, who says that "all bones are at first cartilaginous;" and Coster, holding the same opinion, observed, that for the most part ossification extended from the centre of bones. According to Bartholin, "the entire bony mass in the fœtus is at first fluid, next tendinous, then cartilaginous, and finally acquires the solidity of bone." Kerckring held that

* See Weber, *Allgemeine Anatomie*, p. 315.

† See Miescher, p. 49.



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Zoology. membrane preceded the cartilaginous stage, whilst Nesbitt and Boehmer, admitting the cartilaginous origin of spongy bones, believed that flat and tubular bones at first consist of a double membrane, between the layers of which, from its very first production, hard osseous matter is deposited. Duhamel maintained that the periosteum is the organ in which the cartilage to be converted into bone by the addition of lime, is prepared, and that each internal lamina of this membrane is changed into bone, so that by a repeated deposition of such laminæ, the bone thickens. This notion was confuted by Haller, who, after reciting the opinions of various other writers, observes, that the short fibres of the cellular structure of the periosteum does not correspond with the longitudinal fibrous texture of bone; that ossification takes place within bone where there is no periosteum; and that at the very time when bone is formed from cartilage, the periosteum is most imperfect, and inefficient, very thin, and destitute of vessels carrying the ossific liquor, and from its great tenuity has no lamina which it could deposit for conversion into bone. Also that bone is first produced in the centre, where its connection with the periosteum is least, and that the laminæ of the latter increase only in proportion to the perfection of the bone.

Albinus insisted on the primary cartilaginous nature of all bones, and denied that it was ever membranous, observing that "although such might seem to be the case in the large thin bones, as those of the top of the skull, yet that their membranous appearance was really cartilaginous." And he also made the remark that "cartilage was not always alike; that at first it was a delicate jelly, both in softness and constitution; that subsequently as this tender cartilage grew, it gradually solidified, at the same time whitened, lost its transparency, and at last, after a long while, became hard, white, thick, and concrete."

Haller, in his beautiful observations* on the incubated egg, gives an account of the gradual evolution of bone. Setting out with the statement that "the commencement of all bones is gelatinous," he observes, that so soon as the long bones become apparent, they are found to consist of a chrystalline jelly, are flexible, every where accurately defined, with no distinction of parts, but with their rounded heads, condyles, and the precise shape which they have in the adult bird; they are entirely colourless, without fibres, laminæ, holes, medullary appearance, or cavity. About the 186th hour, and prior to the appearance of blood, some opaque particles are seen in the middle of the bone, which, when examined with the microscope, are found running in lines, with slight ridges on either side, and following the longitudinal direction of the bone, which now has lost much of its flexibility, and if forcibly bent, at first flies back to its original shape, but soon after breaks asunder in the middle, or the epiphyses separate from the body of the bone, although they seem so closely fitted to it that even with the microscope they are not a line apart. About the tenth day the large nutritious vessels of the thigh are perfected, and continued into red canals; at the same time the longitudinal lines and the opacity increase, so that more and more of the bone grows yellow, and at the conclusion of this day appears rugous; wrinkles, also, which are incipient fibres, are observed in the part previously cartilaginous, and if dried the opaque part is now found to be bony and capable of supporting itself in the shape of a hollow cylinder, whilst the cartilage becomes wrinkled. During the following day the bone begins to redden, the opaque part first colours, then actual red spots appear in the tibia and the thigh bone, and the whole bone becomes red. At the close of the twelfth day, or later, there is a row of red spots in each bone, the course of the nutritious artery is now visible from the point where it enters its canal to the marrow, which also reddens; and lines of parallel vessels, stretching into the hollow of the bone, are observed; the tube of the bone at this time consists of numerous spongy laminæ, at its central part, but, expanding at its epiphyses, has there but one. An internal delicate vascular periosteum now appears, which is for the investment of the medulla; and two-thirds of the length of the bone are able to support itself, and have assumed a true osseous character. If now the bone be stripped, between the grooves and in the pores there are seen innumerable little vessels, like spots of bloody rain, which were the spots already mentioned, and in the more developed bone subside into little lines. Bony threads also, in form of white lines, stretch through the cartilage to the epiphyses. Towards the conclusion of the fourteenth day the vascular circle of long arteries from the nutritious artery have increased more and more in number and length; they are contained within the tube of the bone parallel to its axis, and branching, pass between the raised plates to terminate at the extremity of the bony part. During the two following days the vessels are very full of blood, and the bone itself is almost perfected. Long straight vessels, together with subnascent cellular tissue, pass between the larger plates, and descend to the extreme boundary of the bone, the cartilaginous part of which, now reduced to a mere delicate plate, is adapted to the epiphysis by alternate little elevations. From the laminæ forming the shell itself numerous plates are sent into the cavity, which near the centre of the bone are very short, but become longer as they approach the epiphyses, the inner being most and the outer least reticulated. At length, on the seventeenth or eighteenth day, the bone is completed, its interior laminæ become solid, the vessels, which had resembled points and lines, are gradually covered by the supernascent laminæ, and even the vascular circles being concealed, the whole bone, or rather its central part, now becomes fragile and hard. With regard to the epiphyses, which still remain to be adverted to, Haller says that although at first they formed part of the bone, yet subsequently they separate from it, and carry away the periosteum closely investing them; subsequently, however, an irregular rough surface, partly tubercular and partly hollow, is formed on them, by which they are again connected to the tube of the bone, but at the seventeenth day of incubation are still found entirely cartilaginous. The vessels of the vascular circle are now exceedingly numerous, and not merely disposed around the periphery of the end of the tube, but by their ramifications fill up its entire area, and terminate in a clublike shape. Some of these, two or three, on the eighteenth day, penetrate into the cartilaginous epiphysis, and as their number increases, the ends of the tube opposite the epiphysis form a cribrous and vascular hemisphere, completely perforated by vessels, which entering the epiphysis in every direction, form arches from whence straight vessels are given off. Besides these, another set of vessels

* See his *Elementa Physiologiæ*, vol. viii. p. 317, *et infra*.

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Zoology.

wind round the cartilage, and entering by a depression into its substance, anastomose with the former, and fill it with a net-work of red branches. And at length, about the time when the chick bursts its shell, there is found in the epiphysis a white, bony, cellular, and always rounded nucleus, which is full of cavities: those cells which are nearest the centre being larger than the more distant, and always following the course of the vessels. As the nucleus grows it presses the cartilage, thrusting it against the crust which terminates the bone opposite the epiphysis, until it occupies the entire space in which the latter had previously existed, leaving only the thin cartilaginous layers seen on the articular surface. And thus the whole bone is perfected. From these observations Haller concludes that all the phenomena occurring in the conversion of cartilage into bone "commence with the first appearance of the arteries, proceed in correspondence with their growth; that there is no formation of bone from cartilage, nor any distinct structure in bone, unless it be pervaded with red blood;"* for he had previously insisted that "so great is the bulk of the earthy particles in the osseous juice coming to bone, that it can pass by none other than red vessels, and those so dilated as to carry distinctly red blood."

Scarpa, in his account of the progress of ossification in the incubated egg, concurs in the appearances of the changing cartilage as mentioned by Haller, but denies the existence of fibres and plates; he says "these very delicate beginnings of ossification observed with a glass of no very great power, distinctly show and prove that the nature of bone is, at first, by no means fibrous, but is entirely, both externally and internally, *reticular*, *cellular*, *and cottony*, and that it is most decidedly made up of very short spaces or little masses, (*ex brevissimis tractubus, globulisve*,) coalescing at acute angles," and that in longitudinal sections of the femur and tibia, "their walls are everywhere *tomentose* and *cottony*, and that there is none, or the least trace of *tables* or *superimposed plates*."†

From 1799, the period at which Scarpa's observations were published, till 1815, when Howship again took up the subject, no further inquiries were made into the minute structure of bone. His observations‡ were made almost entirely on the extremities of bones, with the solar microscope, and in some instances after calcination. In a human fœtus of eight weeks he describes rings of bone in the situation of the metacarpal bones and of the first and third phalanges, and soft parts in the situations of the joints, consisting of a yellowish transparent gummy matter in which *no appearance of cartilage* could be discerned. At ten weeks the extremities of the bones were found connected together by a cartilaginous substance, sections of which exhibited irregular cavities filled with a mucilaginous fluid; and in one section a smooth cavity was detected, which extended into an even canal or tube passing down to the surface of union between the cartilage and bone. At seven months in a finely injected fœtus, all the cavities had become canals which traversed the cartilage, now comparatively firm, in various directions, and several of the largest proceeded to the ossifying surface which was slightly tinged with the colour of the injection. In a newly-born child these canals were filled with a peculiar colourless, glairy, or mucilaginous fluid, and from the edge of the newly formed bone there was an appearance of small, short-pointed villi shooting into the substance of the cartilage, which at this part was, for about one-twentieth of a line, rather more opaque than elsewhere. By calcination of the lower part of the thigh-bone of an infant of three weeks, from which a longitudinal section was taken, it appeared that the ossific masses became more numerous, of a lighter substance and thinner texture as they proceeded from the middle to the extremity of the bone, and that the earliest state in which the particles become apparent after having cohered, is "as an assemblage of the finest and thinnest fibres moulded into the form of short tubes, arranged nearly parallel with each other, and opening externally upon the surface connected with the cartilage; they appeared corresponding in number to the villi just mentioned. On the surface they terminated by small apertures, and here also were seen larger apertures corresponding to the canals previously existing in the cartilage and running beyond the surface of ossification. At eleven months the canals within the cartilage were very few; at eleven years were still diminishing, and at seventeen years there was scarcely a trace remaining. The same canals were also seen in the cartilages and ossifying extremities of the bones of the fœtal calf, furnished with membranous linings, which Howship speaks of as being injected, but it is evident he means only coloured with injection, probably from extravasation, as he says, "in many parts of the cartilage where the lining of the canals was finely injected, there was no appearance of *distinct* vessels, although to those canals that were opened at their origin upon the external surface of the cartilage, a distinct artery full of the injected matter might generally be traced passing inwards to some extent."* In the flat bones, those of the skull, in a fœtus of ten weeks, the radiated disposition of the ossification was visible, and many small portions of bone detached and at a distance from the larger ossific radii. Probably at this period, though not mentioned, as subsequently at the thirteenth week, the reticulated structures connecting the membranes to the bone with the interspaces of the ossific fibres were filled with stiff, glairy coloured mucilaginous fluid perfectly similar in sensible properties to that in the membranes lining the canals in the cavities of long bones. The conclusions† to which Howship comes from his observations are that in mammals the first rudiments of ossification in long bones result from "a secreting power in the arteries upon the internal surface of the periosteum, producing a portion of a hollow cylinder, this form of bone having been found antecedent to the evolution of any cartilaginous structure; that for greater expedition, cartilage is subsequently formed, the cavities and canals of which, lined with vascular membrane, secrete so abundant store of gelatinous matter, which also assists in determining the future figure of the bone, "by establishing and conducting the ossification within its own substance;" that under the microscope cartilage appears to be "an even and finely granulated albuminous matter, deposited in the interstitial spaces of an exceedingly elastic bed of a semitransparent, reticulated structure, which is apparently a modification of gelatin;"

* *Ib.* p. 331, *et infra*.
† See Scarpa, *loc. cit.* p. 11.
‡ See his *Experiments and Observations on the Formation of Bone*, in *Med. Chir. Trans.* vol. vi. p. 263.

* *Ib.* p. 270.
† *Ib.* p. 283.



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that "the ossific matter in the cylindrical bones is deposited primarily in the form of fine, thin, tubular plates;" that whilst the capillaries between the cartilage and the bone must provide the phosphate of lime, the cylinder is lengthened, and the progressive changes in a growing bone are effected by "simply the mechanical pressure exerted by the fluid secretions within the medullary cavities;" that a very slow and uniform motion of the blood through the capillaries is most favourable to ossification, and that the numerous inflections of the minute pericraneal vessels, and the rectangular giving off of those of the dura mater, as also the extremely curious appearance of the blood and injected matter upon the fine membranous linings of the canals in cartilage, "indicating," as he believes, "something beyond a mere capillary circulation, are to be considered as so many evident provisions for securing this condition:" that, in cylindrical bones, the ossific surface is arranged in tubular plates of a larger and smaller size, which, however, is not essential, because not always found; and that the use of the larger tubes appears to be only for increasing the quantity of blood circulating through the ossifying structure, and thus to increase the rapidity of the growth; that in cylindrical bones and those flat ones formed on cartilage, "the deposit of the ossific secretion is in the first instance made around the external openings of the smaller series of tubes, and upon these only;" and that "the ultimate texture of bone is not laminated but reticulated, the phosphate of lime being deposited as an interstitial substance."

According to Purkinje and Valentin, immediately after the appearance of a transparent, vitreous substance in the blastema, the bony canalicules are first observed, which in every bone form a peculiar, definite, and characteristic system, and in their origin accord precisely with the blood-vessels, inasmuch as the round cavities which first appear in the previously solid mass, and primarily of a globular form throughout, soon elongate in their middle, and thus form a canal rounded at each end, by which they are joined to each other, and so form the first true bony canalicule. This formation of canals is observed in every rudimental bone prior to the first points of bone being visible to the naked eye, or in the still soft and cartilaginous investment of the first white and opaque streak. The younger the embryon the larger are these canalicules in proportion to the size of the bone, and their diameter is but little increased in the adult. The bony corpuscules are metamorphosed granules of the blastema, and their transition can be distinctly observed, passing from their early rounded form by manifold shades into the proper, oblong bone-corpuscules with both ends sharply pointed. The bone-fibres, more properly the bone-substance, are merely the thin septa passing in more or less parallel direction where the canalicules are fewer. They differ not from the other bone-substance, and every such division of them is not merely superfluous but erroneous. The bony mass is taken more or less homogenous and transparent, containing parallel or concentric fibres, which appear not to be singly divided, but consolidated into a mass. At the moment when the primary granules become rarer, the mass attains more transparency, and assumes a peculiar chrystalline appearance. The unossified cartilage remains in a lower stage of development; the transparent mass is less, but the number of corpuscules on the contrary are larger than in bone. As development proceeds, they separate more from each other, though at the first, indeed, they were separate, though only by very small interspaces. Their arrangement, although no linear disposition of any kind is observable, is, however, so elegant that a regular arrangement is observed at first sight; and both in the embryon and adult they are of a more rounded form.*



The recent observations of Miescher† upon the development of bone were made on fœtal rabbits, from ten to twelve Paris lines in length, in which he found the long bones of the extremities fully developed, but still soft and flexible; in most, however, their bodies exhibited some bony matter, the necks of the ribs and their junctions with the sternal cartilages were also ossified, but no spot of earth existed on the vertebral column, and the investment of the brain appeared soft and membranous. All the cartilaginous parts were covered with a thin membrane, the rudimental periosteum easily separated, excepting only at certain parts, as the articular extremities, where it was more closely adherent. Beneath this, the pellucid cartilage presented a regular smooth surface, of a dusky red colour throughout, and thus distinguished itself from the harder yellowish, or yellowish-white cartilage, in which ossification had commenced. Having placed a fibula, entirely cartilaginous, under the microscope, he found it distinctly regular, pellucid, without any trace either of fibres or plates, and without any distinction between the body and ends of the bone. Its interior, however, consisted of an immense number of pellucid, ovate corpuscules, of a dusky colour, without any regular arrangement, but in general their long diameter was placed transversely, and they were separated from the other pellucid, cartilaginous substance by a well-defined line, somewhat more dusky on the one side. When the light fell upon them from above, the corpuscules had a milky appearance, and the surrounding pellucid matter was blackish. In the middle of the bone they were more closely approximated, and seemed more opaque and less pellucid. A portion of the middle of the thigh bone, about one-eighth of a line in circumference, was white, firm, and no longer pellucid; its surface was still soft like the fibula, but the osseous part, irregular and wrinkled, exhibited no definite structure, and joined on both sides, by a denticulated edge, the cartilage, of which it occupied the whole thickness. On making a longitudinal section, the cartilage, where in contact with the ossified part, was found to be more pellucid than elsewhere, its corpuscules more distinct, of more equal form, and farther apart. The bony edge seemed to consist of segments of circles regularly arranged with their cavities towards the cartilage, and each containing a single corpuscule in every space; but as the segments approached the middle of the bone, they gradually became converted into circles, containing the corpuscules in their centres; and the circular lines having become wider and wider, the spaces between them and the corpuscules were diminished, till at last they disappeared, and in the middle of the bone there remained only an appearance of round spots, scarcely to be perceived. The only difference apparent in a transverse section was the more rounded form of the ovate corpuscules, but neither medullary tube nor canalicules for vessels could be perceived. When a

* See Valentin, *loc. cit.* p. 263.
† See *Op. cit.* p. 13.

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single drop of dilute muriatic acid was thrown upon it, the opaque mass became transparent, the cartilage only, with its scattered corpuscules, remaining; but when a portion of the bony part was dried, it was of a milky colour, and seemed to consist of the most delicate pores, like those of pumice stone. "Therefore," says Miescher, "ossification first takes place where the cartilage hardens around the corpuscules by receiving earthy particles; hence an immense number of bony vesicles or cells are produced, each of which contains a single corpuscule."* In examining a frontal bone, of which the ossification was farther advanced, the opaque supraorbital edge presented, under the microscope, the roundish apertures of canalicules tolerably large, and which, penetrating the substance of the bone obliquely, and joining each other, were transparent. These apertures towards the thin edge gradually subsided into single holes, obliquely perforating the cartilaginous leaflet, from which each particle became thinner, and somewhat forming a depression or semicanal; at length also this oblique kind of little holes disappeared, and instead of canalicules, gaps became visible, which in their turn, at the still soft edge, could no longer be observed. At this part the substance was regular and transparent, largely interspersed with nearly rounded globules of a more dusky tinge than the other colourless substance: they were also seen in those parts into which earthy matter had been received, and differed in no respect from the corpuscules seen in long bones, except in being rounder. Miescher considers the examination of the epiphyses, in which ossification is continued long after birth, of greater importance, not merely as showing the mode in which the single nuclei become ossified, but also in what manner the diaphyses increase. If a vertical section be made through the articular head of a bone, there are seen, where the spongy part of the diaphysis of the bone terminates, three streaks of different form and density: the one, hard and white, envelopes the cellular and reticular end of the diaphysis like a delicate rind; a second is more or less dusky, and the third differs from the other cartilage in presenting to the naked eye delicate, short, parallel streaks, whence the whole surface seems to consist of erect fibres. Whatever nucleus already exists in the head is inclosed between the two former, but the third fibrous one is plainly deficient. At the parts occupied by the two latter streaks the substance is softer, so that the epiphysis can be easily separated from the body of the bone, more especially if macerated for a short time in water, and that hard crust alone remains which formed the first zone, and covering the end of the diaphysis, surrounds, as with a delicate crust, the internally cellular bony nucleus. An immense number of rather large and red canals pass in every direction through the cartilage, commencing on the exterior of the epiphysis, and at first converging towards its centre, but so soon as they have penetrated a short distance (a line or a line and a half), they begin to ramify and enlarge, still running towards the centre, where they coalesce and form a dense net-work. These were formerly considered to be vessels; but Howship says they are lined with membrane containing many vessels; Miescher, however, considers that he merely observed a quantity of extravasated injection. The latter author states that he himself observed wherever "any canalicule opened on the external surface, there a small vascular branch entered, which immediately distributed single branches into the lateral canals. The vessels mostly ran in the middle of the canals, sometimes nearer their walls, and always surrounded with a transparent, semifluid, gelatinous, generally colourless substance, but now and then dusky and turbid, as if tinged with blood. This substance was so tenacious that it could be turned off with a needle, but directly recovered its place: it filled the greater part of the cavity, and in proportion as the canalicules ramified more, and enlarged more towards the middle of the cartilage, just so its quantity increased, and the vessels became more minute, the very delicate vascular net-work, in which also the middle branch is lost, produces the fluid."* Miescher could not imagine that these vessels were lost in the cartilage itself. He seems to think that the canalicules to the cartilage are the same as the medullary canal is to bone, as from both can be withdrawn a soft substance abounding in vessels, and excepting these vessels, neither in the osseous nor cartilaginous tissue can any thing else be observed. And having withdrawn this fluid, to which he thinks, not inaptly, the term *Marrow of the Cartilage* may be applied, the walls of the canalicules appear milky, turbid, not transparent, and softish. With regard to the ossification of the epiphysis, it appears that the corpuscules in the cartilage most distant from the ossifying part are densely collected, without order, and somewhat wedge-shaped. As they gradually assume an ovate form they become regularly arranged, mostly in double rows, with their long diameter corresponding to the breadth of the epiphysis, and where the masses of corpuscules are separated by larger intervals of cartilaginous matter, a beautiful and symmetrical appearance is produced. Approaching the place of ossification the corpuscules increase in size, are farther separated, and the rows are more distant; the whole mass seems swollen, the surrounding cartilaginous matter becomes more opaque, of a yellowish-white colour, and surrounds the corpuscules as with a halo. Opaque streaks, like the teeth of a comb, now appear shooting from the extremity of bone into the cartilage, receiving between every two, one or more rows of corpuscules, which, gradually increasing in size, coalesce behind, and thus close one side. With this, other spaces surrounded with opaque substance containing corpuscules touch, and when the cartilaginous matter between the latter loses its transparency, the primary osseous tissue commences as in the tubular part of the bone, and larger intervals or canals forming in it enlarge, and, coalescing, subside into the spongy substance of the bone; and wherever the walls of the canals are more transparent, there are seen the same ovate, oblong, but not regularly arranged, corpuscules. Miescher says that he never could discover any communication between the canalicules of bone, and those of the cartilage, as stated and depicted by Howship. He observed they were filled with a thin transparent, generally reddish, fluid, giving their walls a purplish appearance, and when injected an immense quantity of vessels were seen spreading over them and pouring out the fluid; he therefore considered that the vascular hemisphere which Haller always observed at the edge of the diaphysis, consisted of these canalicules, and he sums up the whole subject of ossification in the following manner. The stratum about to be converted into bone seems swollen with a great number of very

* See Miescher, *loc. cit.* p. 14.

* See *loc. cit.* p. 17.

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minute short tubes, placed vertically and close to each other, with their mouths opening towards the cartilage; into each tube a row of corpuscules is received; behind these tubes, which are from 0·0200—0·0316 of a line in size, is a second row, in other respects similar to the former, closed on both sides, and forming ovate cells; and finally, when the corpuscules contained in them have further separated by long partitions, a regular tissue is produced, with larger cells again divided into smaller; much the same state of things as in the ossification of the tubular bones of the fœtal rabbit. "This tissue forms the crust, the first of the zones already mentioned, which covers the spongy end of the diaphysis; the first series of tubes is situated in the red streak; the third zone, entirely cartilaginous and fibrous, is distinguished by the regular arrangement of the corpuscules."*

Admitting with Miescher the identity of the corpuscules of cartilage and bone, Schwann holds that the change in shape must take place during ossification, which must depend "either on the thickening of the walls of the cells, and the continuance of the porous canals in them, or upon conversion of the round cartilage cells into starlike cells;" and he prefers the latter opinion, because there is a very striking correspondence between the starlike cells of bone and those of pigment, whilst as to the former no animal substance presents any analogous porous canals. The matter filling up the space between the corpuscules he considers to be the intercellular substance, though probably the walls of the cells also assist. The earthy matter is primarily deposited in this intercellular substance, and probably at a later period in the cavities of the cells also. At first the substance often appears dusky and granular, but subsequently the granules disappear. If it be assumed, as is most probable, that the lime in bone is not disposed in finely divided granules, but connected to the cartilage in some mode analogous to chemical combination, we may show in two ways how its connection with the lime takes place: either the lime connects itself with a single minute portion of cartilage, so that every, the smallest particle at first contains a minimum quantity of lime, and gradually still more until all the cartilaginous particles acquired their proper quantity of lime; or the lime is at first connected only with some very minute particles of cartilage, but with them in its just proportions, as their capability for saturation admits; the other particles one after another gradually obtain their due quantity of lime, so that the very small particle is not chemically connected with the lime until completely saturated therewith. The latter view seems by far the most probable, on account of its analogy to inorganic combinations, and on account of the granular appearance already mentioned which takes place in the ossification of cartilage."†

As regards ossification, Schwann says that "the lime is first deposited in the proper cartilage-substance in the form of distinct, very minute and dusky granules, which sometimes produce the appearance of an indistinct arch-like streak; but whether the lime is merely deposited without connection with the cartilage, or whether it is connected with it, so that the whole substance is gradually connected with lime, he does not know." After the cartilage-substance is impregnated with lime, the cells also fill, and these thus filled with lime are the bone-corpuscules. But the question now is, what are the fine threads which spread out in a star-like form from the corpuscules. If the lime be removed, the corpuscules are still visible, though very pale, but the threads are not; it is, however, certain there is in the cartilage-substance a correspondent structure, and their indistinctness is explicable by their great delicacy. This formation may also very well precede ossification, but for the same reason not be discernible. As these threads, simultaneously with the filling of the cells, and subsequently to that of the cartilage, contain a more compact and less soluble mass of lime, so is it probable that they are tubules and canalicules which arise from the cells and stretch out into the cartilage-substance. According as the cartilage-corpuscules are the cavities of the cells, the walls of which, thickened and consolidated to each other and with the intercellular substance, form the cartilage-substance, or as the cartilage-corpuscules are the entire cells, and the interstitial substance of the cells is only intercellular substance, so these canalicules are either canalicules which penetrate from the cell-cavities into their thickened walls, or elongations of the cells themselves into the intercellular substance.*

The longitudinal growth of tubular bones takes place in the layer of cartilage between the diaphysis and the epiphysis, in which, by the formation of additional nuclei or cells in the interstitial substance, more cartilage is produced to be converted into bony canalicules and corpuscules till the period at which the determined length of the bone is attained, when this formation of cartilage ceases, and then the remaining cartilage is gradually converted into bone, and the growth is perfected. In proof of these assertions may be adduced the experiments of both Duhamel and Hunter. The former of these writers pierced with a needle at corresponding intervals the leg of a chicken just hatched, and on examination fifteen days after, found the holes much more widely separated. In animals just horn, he observed that the middle of the bone was but little lengthened towards the ends, however it had grown more proportionally, but in the epiphyses themselves the growth was greatest. Mr. Hunter's experiment was also made on the tarsus of a fowl, as follows: two small holes, at a distance of one inch and eight lines from each other, were made by cauterization near the extremities of the bone, which was two inches and ten lines long. After a certain time the animal was killed, and the bone had attained the length of three inches and seven lines; the space between the apertures was one inch and eleven lines, but the increase of the bone beyond the points of cauterization was more than double of the same included between them. In the flat bones their extension is continued by the elongation of the bony rays into cartilage, which is constantly produced around their edges up to the period of the development of the full size of the bone; when the production of cartilage ceases, earthy matter is deposited, and the bone completely formed.

In proportion as bone grows in length or width, its wall or crust thickens, and its medullary cavity enlarges by absorption of the interior of the crust, and by deposition on its exterior surface. Duhamel† proved this by putting a silver ring around the wing-bone of a

* See Miescher, *loc. cit.* p. 19.
† See Schwann, *loc. cit.* p. 117.

* See Schwann, *loc. cit.* p. 33.
† See *Mem. de l'Acad. Roy. de Paris*, 1743, p. 102.

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pigeon; after twenty days, on breaking the bone, the ring was found within the medullary cavity, which corresponded to it in size, whilst the crust of the bone had formed over it. In some of Mr. Hunter's experiments, proving "that a bone does not grow in all its parts, that is, does not grow by addition of new particles among those already arranged, or in their interstices, but by the addition of parts lengthways or sideways of the bone,"* it is related that in a young fowl the tarsus was perforated near each extremity, and a small leaden shot introduced into each hole. After a time the animal was killed, the bone had increased to three inches and ten lines in length, but the distance of the shots which had now reached the medullary cavity was exactly the same as when first introduced. The reddening of animals' bones fed on madder, first mentioned by Misaldus, in 1572, and again accidentally noticed by Belchier, in 1736,† was imagined by both Duhamel and Mr. Hunter to afford proof of the external deposit of new osseous matter on the crust of bones, alternate layers of red and white being produced, according as the animal had or had not madder intermingled with its food. Much stress is not however now laid on these experiments, although it is admitted they prove that "nutrition is going on more actively in the external layers, and therefore that the increment is most especially on the surface of the bone." The increase in thickness of the crust of bone being admitted to take place on its surface, it is interesting to inquire how this is effected, as it must differ from the mode in which the longitudinal dimensions are increased, there being no trace of cartilage on the surface of the bone. Duhamel held that the new matter was produced by ossification of the inner layers of the periosteum, from having noticed that in very young animals the surface of the bone was very soft, and supposing that the small portions of it which came away attached to the periosteum, if that membrane were incautiously torn off, were semiossified periosteal parts. This opinion was, however, refuted by Haller, as in reality the external layer differs only from the entire bone in being soft, whilst it still possesses both corpuscules and medullary canals. Müller observes on this point: "It is quite erroneous to imagine that one organic part can be the nutritive organ of another organic part; to wit, that osseous matter can be formed by the periosteum, that bone can be nourished by periosteum. The osseous substance, as itself is organized, so must itself assimilate. Only inorganized parts which have no vessels, as the hair, &c., are produced from an organized matrix, and sustained by the apposition of new matter. That the osseous substance is produced by the periosteum, I consider to be a barbarism unworthy of the present state of physiology. The bones are supported by vessels from the periosteum and medullary membrane: they die, therefore, if either the one or the other be destroyed to any extent, the outer layer by destruction of the periosteum, the inner by that of the medullary membrane. But it does not follow that these membranes deposit the phosphate of lime in bones. The periosteum is the conveyer of the vessels entering into the bone, hence it dies if the vessels be torn at this part. The nourishment and growth of the bone is effected by the mutual operation of the bony particles between the capillary vessels and the blood."* The explanation of the increasing thickness of the crust of bone given by Miescher is, "that new organic matter is produced in the external layer of the bone itself (by intussusception); that new canals are formed and grow in them; whilst within, the canals, dilated by absorption, subside into the spongy substance, or, as it were, vanishing from the medullary tube." As to the production of the concentric plates surrounding the single canalicules, as well as of those which correspond to the length of the bone, he does not admit its explanation by interstitial growth as in trees, by any secretion as in the horns of cattle, or by præformation in the periosteum, as Duhamel supposed, and therefore concludes, "nothing therefore remains than that we should consider this arrangement, residing as it were in the condition of the vessels, inherent in the osseous tissue itself, by which it purposes subsequently to pass into bone."†

The following observations of Schwann, when treating of the laws for the production of new cells in the cytoblastema, give a very satisfactory description of the mode in which both the concentric laminæ forming the crust of the bone, and also those surrounding the canalicules are increased in number, and consequently the walls of the bone thickened. "The bones, in a manner, occupy an intermediate position between organized and inorganized tissues. The cartilage is at first without vessels, and the new cells therefore form themselves only in the neighbourhood of the external surface; subsequently it contains vessels which penetrate the medullary canicules, but are insufficient to pervade the entire tissue with *liquor sanguinis*, which must besides be rendered more difficult by the great solidity of the cartilage and bone. According to the preceding law, (viz., that new cells are formed only near to where the fresh nutritive matter enters into the tissue,) the formation of new cytoblastema and new cells can only take place partly on the surface of the bone, and partly around these canalicules. If then it be assumed that on account of the solidity of the osseous substance this takes place in layers which are not perfectly consolidated together, the structure of bone appears very simple. It must consist of a double system of layers, of which one is concentric around each canalicule, and the other concentric around the external surface. If the bone be hollow, the layers must also be concentric around its cavity; and if, instead of medullary canalicules, there are medullary cavities, as in the spongy bones, so must the layers be concentric around the cavities."‡

Not only during growth is, to say the least, a change taking place in the relative position of the materials of which bone consists, by the thickening of its crust and the enlargement of its medullary cavity, involving deposition on the exterior and abstraction from the interior, but soon after perfection a tendency to decay begins. The medullary tube gradually enlarges, and, corresponding with it, the crust thins: and these processes continue so long as life lasts: hence, in very old people, it not unfrequently happens, that the crust of a bone, which at the adult period of life is about a quarter of an inch thick, of a very close, solid texture, and of great strength, is diminished to the thickness of a thin card-board, and breaks with the greatest facility, so that

* See *Physiological Catalogue of Mus. Roy. College of Surgeons*, vol. i. p. 41.

† See *Philosophical Transactions*, 1735-6, p. 287.

* See his *Physiologie*, p. 301.

† See Miescher, *loc. cit.* p. 65.

‡ See Schwann, *Op. cit.* p. 202.

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Zoology. by merely catching the toe in the bed-clothes a fractured thigh may ensue.

### Of Fibrous Tissue.

*Tela Fibrosa* seu *Tendinea*, Lat.; *das Sehnige Gewebe*, Germ.; *le Tissu Fibreux*, Fr.

The Fibrous Tissue is largely spread throughout the body in two forms, either cordlike, as tendons and ligaments, or expanded, as in the various sheaths which envelope all the soft parts of a limb, or inclose one or more tendons in their passage over joints, or form canals for the preservation of the soft medullary matter of nerves, as capsules overspreading the surface of joints, and as membranes which envelope the great nervous centre, cartilage, bone and glands.

The appearance of fibrous tissue is silvery and glistening, and the fibres of which it substantially consists are more or less distinctly visible, very slender, sometimes longitudinal and parallel, with a few connecting them transversely, as in the case of tendons and ligaments, so that they can be torn only lengthways, like linen; at other times they are interwoven in an intricate net-work, which will not admit any regular tear, and indeed scarcely any tearing without the greatest violence, of which the dura mater and the sheaths of tendons are examples. The thickness of tendons and ligaments depends upon the quantity of parallel fibres massed together, and connected by transverse fibres, like numerous strings sewn together to form an untwisted cord. The thickness of the sheaths and canals, on the contrary, depends on the superposition of more or less layers of net-work, which are intimately connected with those above and beneath them, and inseparable. Cellular tissue enters largely into the composition of fibrous tissue, or perhaps, more correctly speaking, is largely employed in filling up the spaces between the fibres of this tissue, and upon this point Haller observes, "beginning with the very smallest thread, it will be found to have cellular tissue as its sheath."* It is doubtless on its greater quantity in ligament than in tendon that the greater crispation of the former than of the latter by immersion in boiling water is to be attributed, upon which principally Craigie seems to have founded his division of fibrous tissue into *Tendon* and *White Fibrous Tissue*. Although tendons, and not unfrequently ligaments, appear to be homogeneous and not fibrous, yet can they be separated into fibres not exceeding the size of a silkworm's thread. Beclard says it is not certainly known whether this is the utmost division they will admit of, but thinks probably it is. Leeuwenhoek declares that a hundred fibrils may be counted in a fibre scarcely thicker than a hair, and that he found tendinous fibre of equal thickness both in the fly and in the whale. He says also that in some animals he observed it wrinkled and somewhat folded, and in others spiral. Fontana† describes the ultimate fibril of tendon, his *fils*, or *cylindres tendineux primitifs*, as being twelve times thinner than his smallest nervous fibril: he says that under the microscope it appears homogeneous, and not consisting of globules or vesicles; that throughout its whole length it is of equal thickness, cylindrical, solid, and rather wavy. Mascagni considers that microscopic examination shows the primitive filaments of this tissue to consist of a mass of absorbent vessels enveloped in one membrane formed by these vessels, and in a second formed by a net-work of very delicate blood-vessels. This kind of composition seems to enjoy much of his favour, as he repeats it in his description of the structure of bone. According to Milne Edwards, the ultimate fibres of tendon consist of rows of globules with a diameter of 1-8100th of a Paris inch, and are distinguished from muscular fibre in being less straight.*

The proper vessels of fibrous tissue are few and very minute, but are capable of receiving injection, and according to Mascagni, most of the arteries are accompanied by a pair of veins. The large vessels which are observed on the dura mater, and the very numerous, though much smaller, vessels existing in periosteum, are scarcely to be considered as belonging to either of these membranes, but rather to the parts which they invest, and which require minute division prior to their admission. Of nerves the fibrous tissue possesses but few, and during health is but little sensible; under inflammation, however, it becomes acutely sensible, as is experienced in rheumatic and syphilitic inflammation.

*Chemical Composition.*—Fibrous tissue contains a large quantity of water, according to Chevreul so much as 62·03 in 100 parts; hence its great flexibility and peculiar silvery appearance. When dried, it becomes transparent, very flexible, and loses its fibrous appearance almost entirely, though it will still only tear in their direction; but if again soaked in cold water, it speedily recovers its original character. It putrifies with great difficulty, and after many weeks' maceration has merely swollen and has a flocculent appearance, from the disposition of its cellular tissue to absorb water; and even when its cellular connections are destroyed, its fibrils long continue unchanged. If boiled, it shrivels up, becomes yellowish and elastic, and dissolves into jelly; this change takes place more readily in tendon than ligament, from the former containing less cellular tissue, but it is disputed among chemists whether the gelatine is an actual component of the tissue, or merely a modification of albumen. If burnt, it shrivels up violently as it parts with its moisture, and leaves a large quantity of coal. It is dissolved by the mineral acids, either cold or hot, and nitric acid shrivels it. Alkalies swell and soften it. As in all other organized tissues, so also in fibrous, chloruret of sodium and of potassium are found.

### *Fibro-cartilaginous Tissue*,

So called by Bichat, and described as a distinct tissue, can scarcely be held entitled to such distinction; Beclard has therefore considered it as a modification of fibrous tissue, whilst Weber holds it as a species of cartilaginous tissue. Both are right, if the extreme on either side be taken as characteristic of the whole: thus, Beclard's opinion is borne out by the distinct fibrous appearance of the intervertebral substance, whilst the cartilaginous appearance, for it is appearance only, of the movable interarticular cartilages, or *menisci*, seems to support the correctness of its position with cartilage in which Weber has placed this substance; the observations, however, both of Beclard and Miescher, show that the interarticular cartilages, as well as the intervertebral substance, are fibrous.

The intervertebral substance, by means of which the

* See his *Elementa Physiologiæ*, vol. iv. p. 428

† See his *Essai sur le Venin de la Vipère*, vol. ii. p. 122.

* See *Annales des Sciences Naturelles*, 1826, p. 373.

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bodies of the vertebræ are connected in man, beasts, and fishes, consists of numerous concentric rings of very dense fibrous tissue, which have a whitish or yellowish-white appearance; these rings in man and beasts gradually become of a looser texture and softer as they approach the centres of the vertebral surfaces, so that the vertebræ incline upon each other in any direction, precisely in the same way that two plates would move on each other were a bladder of water interposed between them, the water still occupying the same quantity of space, being confined by the bladder, though the form it assumes varies according to the direction in which the pressure is made, and in which the bladder moves on it. This actually occurs in fishes, for in them the connection of the bodies of the vertebræ, which are correspondingly hollowed into cones, is merely by a collar of fibrous tissue, and the hollow double cone is filled with fluid so completely that if the intervertebral substance be punctured, the fluid spurts out to a considerable height by the mere elasticity of the fibrous ring. The fibrous connection of the pubic bones in the human subject is also of precisely similar character to that of the vertebræ, with the exception of being less soft. The strength of this modification of fibrous tissue is extremely great, and its connection with the bones so firm, that the latter almost invariably break in preference to any laceration either of the tissue itself or any separation of it from the bone.

Besides existing between the vertebræ, this fibro-cartilaginous substance is found where parts are subject to pressure, thus on the tuberosities of the pelvic bones in such animals as are accustomed to sit. It also forms the elastic pads placed between the coffin bones and the hoofs of solipedous and bisulcous animals, without which the sensible sole, or organ secreting the horny sole, would be severely bruised, and the coffin bones themselves smashed to pieces at every step, especially if the animal were running at speed.

### Of Elastic Tissue.

*Tela Elastica*, Lat.; *das Elastisches Gewebe*, Germ.; *le Tissu Elastique*.

This very peculiar and elastic substance, which, existing between the muscles on the back of the necks of cattle and other beasts having either large heads or long necks, so that their head is far in front of the supports of the body, is commonly known by the name of *Parwax*. But it is found in many other positions in animal bodies, where parts are either to be supported or kept together without muscular exertion, in which case it exists either as a band or card; whilst at other times it surrounds tubes which admit of distension, and then taking their form, it is stretched to a certain extent as they are swollen by injection, after which by its inherent property it returns to its ordinary condition when at rest, and so restores the mean calibre of the vessel it surrounds. It was doubtless discovered and first described in Mr. Hunter's great work On the Blood, published in 1794, under the name of *Elastic Ligament*, and its several applications and uses in the animal economy distinctly pointed out. As an independent structure, it has since been constantly spoken of in the English schools, and often under the title of *Ligamentum Subflavum*. It is, therefore, rather amusing to find Blainville, in his *Cours de Physiologie Générale et Comparée*, after slightly observing, " le tissu jaune élastique avait été entrevu par Hunter," very coolly stating, " Je crois avoir été le premier qui, dès 1808, dans un cours spécial d'anatomie de l'homme, ait démontré les caractères de ce tissu et sa présence dans le ligament cervical," &c. &c.*

In its general appearance elastic tissue is yellowish and fibrous, and forms either cords, bands, or tubes, according to the purposes for which it is employed; in the latter case its fibres are parallel and circular, but in the former longitudinal. It is endowed with a high degree of elasticity, so that it will admit of great extension and again revert to its usual length; but if the parts which it connects are approximated more closely than when the elastic tissue has returned to its quiescent state, it shortens no more, but falls into folds less or greater, as it is rendered less or more lax. It putrefies with great difficulty, and when in contact with putrid matter or blood becomes red throughout. When decomposed, it smells but little, and dries of a dark red brown colour. It is distinguished from fibrous tissue by yielding in boiling water only so much gluten as belongs to the cellular tissue which is superadded to it; neither does it become semitransparent. It is, according to Weber, the same substance as the fibrine of the blood and of muscle, and similar to coagulated albumen, from which, however, it is distinguished by certain chemical characters. It is harder and more brittle than muscular or fibrous tissue, and, containing little water, does not lose much of its bulk by drying. Boiling, even long continued, does not convert it into a jelly-like yellow pulp, the fibres remain as they were and their size undiminished. No thick precipitate is thrown down by the addition of tannin, but only a small quantity of somewhat powdery dejection. Bichat says that alkalies, even in their caustic state, act little upon it. Berzelius has examined it in the arteries, and therefrom argues that what is often and improperly called the muscular coat of an artery is not really muscular; and in comparing muscular with this tissue, says, " muscular fibre possesses the same chemical properties as the fibrine of the blood, viz., solubility in acetic acid, and the property of forming very insoluble combinations with sulphuric, nitric, and muriatic acids; but arterial fibre has diametrically opposite properties—it is insoluble in acetic acid, but pretty easily soluble in dilute mineral acids, and in these solutions is not precipitated by alkalies, nor alkalies combined with hydrocyanic acid, although these react on solutions of fibrine."† Chevreul says it differs from fibrous tissue in containing more water, but only, however, sufficient to sustain its elasticity, and if more, it softens and loses this property. As to its chemical elements, little is known: Stauff, indeed, supposes that it contains a substance analogous to gelatine and osmazome, but that it has not either one or the other, inasmuch as it does not dissolve in boiling water, nor solidify into a mass on cooling. He, however, thinks it more like osmazome than gelatine, which leads him to imagine it has some analogy with muscular fibre.

The elastic tissue examined by the microscope consists, according to Gerber's account, of " prismatic, commonly quadrangular, stiff, elastic threads, from 1-550th to 1-400th of a line in width, and of equal size throughout, sharply and distinctly defined, which divide in an angular form, and are connected at acute or

* See *loc. cit.* p. 138.

† See his *View of the Progress and present State of Animal Chemistry*, p. 25, translated from the Swedish, by Brunnmark.



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rounded angles of different size; the intervening meshes are sometimes of equal, sometimes of very different size and form. The elastic tissue of the nuchal band has its fibres stiff, quadrangular, or hexangular, and the meshes are so lengthened, that scarcely any space is left between them, and they require to be spread out laterally to become distinct. The tissue of arteries is more irregular and complicated; its fibres are of different size, and are commonly flat; the interspaces are of various size, polygonal and round. In the so called yellow membrane (*lig. subfl.*) the elastic tissue is tolerably pure."*

Mr. Hunter has well compared the use of elastic tissue with that of muscle. He says, "where constant action is not necessary, muscles alone are employed, as in the greater number of moving parts in most animals; and where any position is required to be constant, and the motion only occasional, from being seldom wanted, there elasticity is alone employed for the purpose of constant position, and muscles for the occasional action. Some bivalves (as the oyster) have a strong muscle passing between the shells for closing them occasionally; but for opening them no muscles are made use of, as this is performed by an elastic ligament in the joint of the two shells, which is squeezed, when shut, by the contraction of the muscle; and when the muscle ceases to contract, the elasticity of the ligament expands it, so that the shell is opened."† Of the use of the tissue, as diminishing the necessity of muscular action, he observes, "animals which have long necks, more especially those whose necks stand in some degree horizontal, or at least project beyond the body, have elastic ligaments placed on the upper side to support the head and neck, so that the muscles have less power to exert in the motion of the head and neck, these ligaments keeping them in a kind of equilibrium. In birds, these ligaments are placed between what may be called the roots of the spinal processes, viz., as far towards the posterior surface of the vertebræ as possible, so as to be behind the centre of motion of each vertebra: but in quadrupeds, whose necks are much deeper or broader, and whose spinal processes of the back rise high so as to give origin to muscles, &c., these ligaments rise principally from the tips of these processes along the back, and, extending forwards towards the neck, pass along its upper edge. In this course they send broad processes into the posterior surfaces of the vertebræ, and are at last fixed in the posterior process of the os occipitis. The long sweep which the ligament makes in the neck, he says, is double, but the processes sent down from them are single. It also connects all the arches of the vertebræ, and Weber correctly observes that the elastic is not, as other tissues, connected with the membrane covering bone, but with the bone itself. Hunter further notices the interesting circumstance of this tissue being employed in assisting to sustain the weight of the abdominal viscera and their contents in animals whose position is horizontal; thus, "on the abdomen of most quadrupeds are to be found elastic ligaments, especially on that of the elephant, which is a constant support to the parts in a horizontal position. . . . . Hence there is less expense of muscular contraction in such parts." In these instances "the muscles and elastic ligament assist each other," as Mr. Hunter says; but at other times "they are antagonists, the elastic being neither assisted by the muscular parts nor the muscular by the elastic." Such is the case with the arteries, the auricular, and laryngeal cartilages, and Gerber also adds some parts of the eyeball, as the iris and ciliary body, which, after the parts have been brought by muscular action closer than is their condition in a state of rest, are restored to their proper form and station by the elasticity of this tissue. And Beclard is disposed to consider the cellular structure of the *corpora cavernosa* as partially made up of elastic tissue. Besides the nuchal ligament in birds, the tendon expanding their wing-membrana, and, according to Nitzsch, many others of their tendons, are formed, or perhaps it might be more correct to say lost, in this peculiar substance.

* See Gerber, *loc. cit.* p. 119.

† See his *Treatise on the Blood*, p. 11.

### Of Serous Tissue.

*Tela Membranarum Serosarum*, Lat.; *das Gewebe der Serösen Säcke*, Germ.; *le Tissu Séreux*, Fr.

The Serous Tissue is distinguished by its disposition in form of large, close sacs, portions of which are thrust into their cavities, so that the parts it invests are actually on its outside, rather than by any peculiarity of ultimate structure which it exhibits. Hence the objections raised by some anatomists to its being considered a distinct tissue are not without foundation.

Under the term Serous Membranes are included two, as may be inferred from the difference of their secretions, distinct membranes, viz., True Serous Membranes and Synovial Membranes; the former invests the chylopoietic, circulating, and respiratory organs, also the brain and spinal cord; the latter overspread the articular ends of all bones forming the boundaries of joints, line the sheaths of tendons, and cover the tendons themselves when ensheathed, and also form simple bags between tendons and bones, or between the latter and skin, where the part requires great facility of motion, or is exposed to much pressure.

#### *a. Serous Membranes*

Include the peritoneum, pericardium, pleura, and arachnoid membrane of the brain and spinal cord, which are the connecting media between the viscera they envelope and the walls of the large cavities of the body in which they are contained. The position of the contained viscus in a serous membrane is, to use a homely simile, precisely similar to that of the head thrust into a double headed night-cap, which, as to the actual surface of the cap, is on the outside, though, by the one-half of the cap being thrust into the other, the head seems, but seems only, to be within it, for if the outer layer of the cap be divided, and the interior exposed to view, the head is not within the cavity. The serous membrane or pleura, by which either lung is invested, can without difficulty be seen in exactly the same condition: by removing the walls of one side of the chest, and cutting off the branch of the air-tube going to the lung, the pleura and lung may be easily removed, the outer surface of the former being exposed, as far as the entrance of the air-tube, and the accompanying blood-vessels, at which point it is distinctly seen thrust in upon itself, and its outer surface closely connected with the lung, which, like the head in the night-cap, is received into the indented bag. That such is the case is further proved by cutting through the pleura and exposing its interior; the lung is indeed seen, owing to the transparency of the membrane, but it is not inside the cavity, for the pleura

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may be here again traced to the root of the lung, and seen to pass over its surface, so that, were it possible to separate the intimate connection of this indoubled portion of the pleura from the lung, an indented bag would be seen, from the outer surface of which the lung had been removed without opening the proper cavity of the pleura. Such is the way in which all the viscera are enveloped, with more or less complicity, by serous membranes, and from the latter, when opened, seeming to bend back upon themselves, they are called *reflected membranes*. Sometimes, as in the belly, the serous membrane does not come immediately on its inflection in contact with the intestine, but continues for some distance upon the vessels which proceed to it: hence, when the peritoneum is opened, the viscus seems to be at the bottom of a long doubling of the membrane, which doubling is called mesogastrion, mesentery, &c., in reference to the parts it overlaps. Sometimes the viscus is not situated at the bottom of the inflection, but some distance above it: to this portion is then applied the term *omentum*, which is analogous to the butchers' expression, the *caul*, between the layers of which, as also between those of the mesentery, a greater or less quantity of fat is found. The reflection of the pericardium and arachnoid membrane is precisely similar to that of the pleura, but neither have correspondent elongations to those of the mesentery or omentum in the peritoneum.

In the human subject and in all beasts, all serous membranes are close cavities, without communication with one another or with the external surface. The peritoneum, however, in the females of both these classes is an exception to this rule, for a small aperture exists in it opposite the floating expanded orifice of each Fallopian tube; and the same also exists in birds and most reptiles, but not in fishes. In reptiles, the peritoneum and pleura communicate freely; and in fishes, as there are no lungs, the latter is of course entirely deficient.

After removing all the parts surrounding a serous membrane, together with the more or less loose cellular tissue, which connect them to each other, the membrane is seen transparent in proportion to its thinness, so that the enveloped viscera can be perceived through their double covering. This external surface is irregular, shreddy, and tomentose, from the tearing through of the connecting cellular tissue, and the minute branches of vessels with which it is supplied, and it exhibits an indistinct, areolated, fibrous character. When its cavity is laid open, the internal surface presents a brilliant, highly polished, and smooth surface, without any appearance of irregularity; but Beclard* says that when put in water and examined with a microscope, it is seen to be overspread with simple villosities. Its texture is tough and elastic, as proved by its distension when the stomach and intestines are distended with food or flatus, and by the non-appearance of any wrinkling in it when those organs are empty and contracted; its yielding also during pregnancy, or distension by any large hernial protrusion, or by dropsy, are other instances of this property. It tears with difficulty and leaves an irregular shreddy edge. After death it gradually loses its transparency, and as decomposition proceeds, becomes more and more opaque, exudes a sort of dirty grumous matter, and at last resolves into shreds. If macerated in water, it becomes opaque, thickens, becomes soft, and separates into a flocculent mass, much resembling cellular tissue. If plunged in boiling water, it also loses its transparency, thickens, and is disposed to shrivel up. If dried, it is rendered very transparent, and its toughness is increased. It is generally considered by anatomists, from Haller to those of the present time, as consisting of condensed cellular tissue, doubtless freely supplied with minute vessels, which in health are incapable, from their small size, of conveying the red particles of the blood, although under inflammation, when the vessels are enlarged, red blood does pass through them, and the membrane then presents their ramifications. Mascagni considers the tissue to consist entirely of absorbent vessels, as these can be largely injected in it; but Meckel says the arteries may also be injected, a very difficult matter, however, except after inflammation. The admission of Meckel that these membranes "are made up almost entirely of a tissue of absorbent and exhalant vessels," is in fact acknowledging that they have blood-vessels, although, as just said, not conveying red blood. The polished internal surface of serous membranes, Rudolphi considers as produced by an extremely thin layer of horny matter; and Gerber says also that it is overspread with a plastic epithelium. When the cavity of a serous membrane is opened during life, a slight steam arises from the polished surface which, after a few moments' exposure to air, becomes dry, and has a slightly clammy feel. This steam, after death, condenses into a fluid, which in health is of extremely small quantity. Portal, Sauvages, and others, maintain that during life this secretion exists only in a steam-like condition; and any one may observe the fact if he watch a butcher dressing an animal just killed. John Davy, however, says he noticed it in a fluid state in the pericardium of a dog violently killed; and Majendie says that, in the arachnoid membrane of both brain and spinal cord of living animals, it is always fluid. Under inflammation, especially if slow, the quantity of this secretion, be it naturally steam or fluid, is enormously increased, so as to amount to many gallons in dropsy of the abdominal cavity.

The chemical analysis of this fluid, commonly called serum, has been made by Bostock and Berzelius.

The pericardial liquor or serum, according to Bostock, contained in 100 parts:

| | |
|---|---|
| Water | 92·0 |
| Albumen | 5·5 |
| Mucus (probably osmazomic and lactic acid) | 2·0 |
| Muriate of soda | ·5 |

The serum from a hydrocephalic patient, according to Berzelius, yielded in 1000 parts,—

| | |
|---|---|
| Water | 988·30 |
| Albumen | 1·66 |
| Muriate of potass and soda | 7·09 |
| Lactate of soda, and with it animal matter (osmazome) soluble in water and in alcohol | 2·32 |
| Soda | 0·28 |
| Animal matter, soluble in water but not in alcohol, and a trace of phosphoric salts | 0·35 |

### *b. Synovial Membranes.*

The apparent structure of these seems to correspond nearly to that of serous membranes; but from the great difference which exists between their secretions, it may be fairly inferred that there is a material difference,

* See page 187.



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although at present undiscovered. Synovial membranes are divided into those which form joints by investing the articular ends of bones, as serous membranes invest viscera, with this difference however, that the inflection of the membrane within itself is double, both ends of the night-cap are thrust in till they meet each other, and the bones to be connected are received into the corresponding cavities. *Secondly*, they are reflected, as the reflected peritoneal covering of a viscus is, over tendons which have passed through a joint, so as to admit of their free motion without the cavity of the joint being open, or in a similar way they line the sheaths of tendons, and are thence reflected upon the tendons themselves; and *thirdly*, they form bags (*mucous bags*, as they have been absurdly called) which are placed either where the large tendons of powerful muscles play immediately over bone, as the great synovial bag interposed between the gluteal tendon and the large trochanteric process of the thigh bone, or where the skin is liable to frequent and severe pressure, as would be the case with the covering of the large projecting process of the elbow, were not a synovial bag interposed between the bone and skin.

These synovial bags are especially interesting, as showing the connection, if not the identity, of serous tissue with cellular, which in its looseness and great extensibility at all parts having free motion, presents "a kind of rudiment," as Beclard calls it, of these bags, which having been inflated, are each found to consist "of a cavity, roundish, multilocular or divided by imperfect partitions, but close; so that the injected air remains in them, and is not infiltrated into the surrounding cellular tissue."* That the meshes of the cellular tissue can be converted into such synovial bags is proved by daily experience, in the appearance of bunions on the feet, which are only such formations to relieve the skin from the pressure of a tight boot or shoe. Sometimes indeed such synovial bags are formed under still more curious circumstances, as the writer of this Essay remembers having seen one formed in the buttock of a young person, in which the point of a sword had been broken off, and after remaining for many months was enveloped in such bag, which being distended with its peculiar secretion, prevented the irritation which the angles of the broken steel would have otherwise produced.

The extensibility of synovial membrane is great, as shown by the large collections of fluid often occurring in joints which are then said to be dropsical, and in the bag between the skin and the knee-cap, or the head of the great bone of the leg, producing the swelling so frequently occurring in housemaids from continual kneeling in the performance of their work, as to have obtained the common name of *housemaid's knee*. So in horses, the distension of synovial membrane from increased contents, as in bog spavin.

Within all forms of synovial membrane, there is at all times a distinct though not large quantity of yellowish-brown, semitransparent exceedingly slippery, but very tenacious fluid called *Synovia*, but in common language, *Joint Oil*. It readily dissolves in water, and soon putrefies. It contains an animal substance which coagulates by heat, and also by the addition of acetic acid, and greatly resembles albumen, and another which neither coagulates with heat, acetic acid, nor alcohol, but is, according to Vauquelin, precipitated by tannin.

* See his *Elémens d'Anatomie Générale*, p. 203.

The chemical analysis of human synovia has been given by Lassaigne and Boissel, and, according to their account, albumen next to water is the principal component; there is also a yellowish, fat, non-coagulable animal matter, chlorate of potash and also of soda, and in the ash after burning, carbonate and phosphate of lime.

Jahn's analysis* of this secretion in the horse is in 100 parts—

| | |
|---|---|
| Water | 92·8 |
| Soluble albumen | 6·4 |
| Non-coagulable animal matter, with carbonate and muriate of soda | 0·6 |
| Phosphate of lime | 0·15 |
| Ammoniacal salts and a trace of phosphate of soda. | |

The old notion of the synovia being secreted by the Haversian glands so called, which are in reality only folds of the lumps of fat included between the membrane as it turns off from one bone to another, is entirely exploded. Nor is there reason for supposing with Rosenmüller that follicles for this secretion are embedded in the fat. "The secretion of synovia is," as Beclard observes, "neither glandular nor follicular, nor the mere result of transudation, but truly perspiratory; the whole extent of synovial membrane is its seat, especially that part which overspreads the fringes (of fat) on account of the greater number of vessels which it contains;" and for this reason it is, that the synovia may seem to be squeezed out from this part.

### Of the Glandular Tissue.

*Tela Glandularum*, Lat.; *das Gewebe der Drüsen*, Germ.; *le Tissu Glanduleux*, Fr.

The term "gland" has been and is still applied to organs of very different kind both as to structure and economy: thus writers speak of Thymus gland, lymphatic glands, salivary and other glands, of which the intimate structure is totally different, and their operations upon the fluids of the animal body entirely unlike, in the one case effecting, it is believed, some very important change in the blood, chyle or lymph circulating through them, but in what respect not known; whilst, in the other, certain parts of the blood are separated from it, and disgorged under forms and with properties peculiar to the several organs by which they are evolved.

In compliance with ordinary usage, Weber divides glands into two kinds, those which have not any excretory duct, and those which are so furnished—this division is also employed by Müller.

### I. Of the *Vascular Glands*, Weber; *Vascular Ganglia*, Müller.

The expression gland, as applied to the structures included under this head, is not held by Rudolphi to be correct, inasmuch as he considers them made up of an interweaving of vessels, either sanguineous or lymphatic, in which notion he is supported both by Weber and Müller, the latter of whom speaks of them as consisting almost entirely of a vascular structure. They are hanks of vessels, vascular ganglia, *Gefässknoten*, the circulating vessels entering into their composition dividing to infinity in the parenchyma itself, and thence again col-

* See his *Chemischen Schriften*, vol. vi. p. 148.

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Zoology. lecting into efferent or returning vessels.* They doubtless effect some very important change in the fluids which pass through them, and which Müller calls "a plastic influence," though what this influence really is remains to be discovered: whatever it may be however, thus far is certain, that it takes place in the vessels, and that the fluids acted on hold their course through the vessels, and are not discharged from the circulation, for which reason excretory ducts are not required, and therefore not possessed by these organs. They are divided, according to the fluids which pass through them, into two kinds.

a. The *Sanguineous* or *Blood-vessel Glands*, Weber; or *Sanguineo-vascular Ganglia*, Müller.

These organs are only found in vertebrate animals, not indeed in all of them, and sometimes only during part of life. The Spleen, which is presumed to belong to the digestive apparatus, is found, with but very few exceptions, in the entire series, and throughout the whole life. The Thyroid gland, situated in front of the top of the windpipe, is also permanent through life. The Suprarenal capsules exist in man, beasts, and birds, and are rudimentary in reptiles; they are also found in the sharks and rays among fishes. In the human subject, they are earlier formed, and more fully developed in the fœtal state than the kidneys, above which they are placed; but in beasts, Müller says, he has never found them at any period larger than the kidneys. The Thymus gland, situated behind the breast-bone, and rising up in the neck, the part vulgarly known as the "throat-sweetbread," is proportionally of very large size in the fœtus, and continues growing for the first year after birth, at least in the human subject, subsequent to which it gradually shrinks, and at puberty has entirely disappeared. It doubtless plays an important, but at present unknown, part in the fœtal economy. The Placenta, or Cotyledons as they are called, when, as in many beasts, there are several of them, are specially formed for the connection of the embryon in the womb to the parent, and for the adaptation of the blood to the fœtal circulation. They exist only in the human subject and in beasts, and after the birth of the young animal are speedily expelled, their function having terminated so soon as respiration and digestion have commenced.

The Spleen is enveloped in a tough fibrous covering, which sends inwards numerous processes, forming septa or partitions, by means of which the soft, pulpy, red substance or tissue of the organ is suspended. This tissue is made up of distinctly reddish-brown granules, as large as blood corpuscules, but differing from them, in that they are not flat, but irregularly globular. They are easily separated from each other, and amongst them ramify pencils of small arteries, which pass into numerous freely anastomosing canals, by which the blood is brought from every part of the organ into the venous trunk. When carefully examined, the pulpy substance appears perforated in every direction, and consisting of a net-work of red septa, the diameters of which are greater than the spaces and canals between them, which are venous, and when injected with air from the veins have a cellular appearance, but are not really cells. Within the red mass, Malpighi discovered in the ox, sheep, goat, hedgehog, and mole, some whitish round corpuscules visible to the naked eye; these, however, according to Rudolphi, do not exist in the human subject, nor, according to Müller, in many beasts. Dupuytren and Assolant describe, in the human Spleen, corpuscles of a greyish colour, very soft, so that they easily tear in raising with the knife, solid, and with a diameter of from one-fifth to one Paris line. Meckel speaks of them as whitish, roundish, and probably hollow, or at least very soft corpuscules, very vascular: of their use Müller cannot give any opinion; but they differ from the clustered corpuscules of Malpighi observed in the ox, sheep, and swine, when the spleen is cut, or still better when it is torn or macerated: in the latter case, the pulpy mass becomes softer and darker coloured, but the corpuscules remain for a longer time of a greyish white, and undissolved, and are seen to be connected together by threads. According to Müller's account, these corpuscules are from one-seventh to one-fourth of a line diameter in the swine and sheep, but larger in cattle; they are roundish, sometimes oval, and almost of equal size throughout. They are not distinct, but each sends out processes on one or both sides; more rarely they are connected with each other in a row like knots on a string, each however sending out fine radicles. More commonly they are attached by necks to thinner threads, which are the branchings of other threads, but more frequently they are fixed by a narrower or broader base upon the sides of branching threads. These threads, which are distinctly hollowed, can be traced back as ramifications of larger ones, which are decidedly branches of the splenic artery. These arterial branches are surrounded with a white sheath, which commences imperceptibly on the branches of the splenic artery, and accompanies them to their most minute ramifications. Their thickness does not however diminish in accordance with the diminished size of the arterial ramuscules, but remains the same, viz., from nearly one-eighth to one-fourth of a line. Upon these sheaths, which are distinct from the septa sent in by the fibrous covering of the spleen, the corpuscules are attached, and indeed, Müller says, "are mere growths of the white sheaths of the small arteries;"* but the arteries are not distributed to the corpuscules, they either pass on their side or directly through them, sometimes however dividing into small branches, whilst taking the latter course, but always passing out of the corpuscules to be distributed in a pencil-like form in the pulpy red substance. The corpuscules contain a fluid, white, pultaceous matter, consisting almost entirely of large corpuscules about the size of the blood-corpuscules, not however flat, and irregularly globular; in shape they correspond exactly to the granules forming the red substance of the spleen.

The Thyroid gland has no proper capsule, and is merely covered with condensed cellular tissue. It is of a reddish-brown colour, and smooth externally, but made up of little rounded irregular lobules, each surrounded with its cellular sheath. The tissue of these is compact, and composed of blood and lymph vessels, the coils of which, connected with cellular tissue, form the lobules; but no cavities are observable, although, when an incision is made, a large quantity of fluid, like the serum of the blood, escapes. Many of the older

* See Muller, *Physiologie*, p. 417.

* Muller, *loc. cit.* p. 554.

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Zoology. anatomists considered that this gland was furnished with excretory ducts, which opened into the upper part of the windpipe; it is certain, however, that this notion is erroneous. During fœtal existence, the Thyroid gland is proportionally larger than at other periods, and is therefore supposed to have some peculiar connection with that time of life, but its use is entirely unknown. The enlargement of this gland, often very great, is known commonly in this country as the *Derbyshire neck*, and in Switzerland as the *Goitre*.

The Suprarenal capsule, or glands, consist of two substances, a toughish, external, yellow or cortical part, and a softer, medullary, reddish-brown interior; the two are are often intermingled so as to produce a mottled appearance. The external or cortical part is made up of straight tubes, which are blood-vessels, and pass from without inwards and parallel to each other. The surface is covered with a net-work of capillary blood-vessels, which are but little smaller than those within the cortical parts. The medullary part has a very loose structure, consisting principally of a venous tissue emptying itself into the suprarenal vein, from which the whole gland can be inflated with air; its use is entirely unknown.

The Thymus gland is situated partially in the chest, and partially in the lower part of the neck; in the human subject it consists of two lateral lobes of an isosceles triangular form, the bases of both being within the chest, and their upper angles in the neck; but in the calf, the great mass of the gland is in the chest, and processes are sent up into the neck, which thin as they ascend to the thyroid gland. They are covered with cellular tissue, and, when this is removed, are found to consist of numerous lobules, varying in size from a pin's head to that of a pea. Sir Astley Cooper states, that they are disposed in a serpentine form, being connected by blood-vessels and mucous membrane, about a cavity or reservoir. Each lobule contains a little cavity or cell, with a pouch at its base into which the secretion escapes. The reservoir forms a general communication for all the cells, and into which their pouches empty; it varies in size at different parts, being largest in the thoracic part, but least where passing from the chest to the neck. It is lined with a membrane, which first seems smooth, but on closer inspection is found to be villous and highly vascular. Ridges appear upon it separating and encircling the mouths of the pouches which empty into it. These mouths are not however so numerous as the pouches themselves, as more than one terminates by the same common cavity. When cut into, these several cavities are found loaded with a great abundance of white fluid, having the appearance of chyle, viz., white like cream, with a small admixture of red globules. And from chemical examination, it appears generally to possess the component parts of the blood, excepting that the particles are white instead of red. Of its use nothing is really known. Hewson thought it formed the internal part of the red globules of the blood, of which the exterior was produced by the spleen, and held it to be "an appendage to the lymphatic glands for the more perfectly and expeditiously forming the centrical particles of the blood in the fœtus and in the early part of life." But Sir Astley Cooper very properly dissents from this opinion, showing that the conglobate, firm, and vascular structure of the absorbent or lymphatic gland has no resemblance to the loose, pulpy and cellular structure of the Thymus. He observes, it is evidently connected with fœtal existence, as it gradually lessens after birth, and inquires, "Is it not probable that the gland is designed to prepare a fluid well fitted for the fœtal growth and nourishment from the blood of the mother before the birth of the fœtus, and consequently before the chyle is formed from food? and this process continues for a short time after birth, the quantity of fluid secreted from the Thymus gradually declining as that of chylification becomes perfectly established."* Zoology.

The Placenta consists of two parts, that which belongs to the embryon, and that which specially belongs to the parent. The fœtal portion is produced by the chorion or external membrane of those in which the embryon is inclosed, the outer surface of which is overspread with numerous delicate villi or folds, in some animals so continuing throughout the whole period of fœtal existence, in others collecting into a zone; in some forming numerous masses or patches, called *cotyledons*, in some only two, producing a double placenta, and in the human subject the entire villi are collected, about the third month of gestation (according to Wagner), "upon a particular spot where they grow with great luxuriance, the rest of the chorion becoming in the same proportion smooth."† These villi, Weber states, although at first simple, subsequently grow into large and numerously divided stems and branches, into each of which penetrates a branch of the umbilical artery and vein, and run to the very extremity of the branched process where the minute divisions of the artery come together in coils or loops, mostly not simple, and frequently forming by anastomoses of two adjoining capillaries. Each of these trunks, with its covering of chorion, forms a lobe of the placenta, and between these, and enveloping them, are received prolongations of the tunica decidua of the uterus, in which the uterine arteries and veins do not divide into branches and twigs, but form a net-work, the canals of which are too large to be called capillaries, but their walls are so delicate that they cannot be separated by dissection. The object of this structure seems to be that the minute, convoluted, greatly elongated, and extremely thin-walled capillaries, in which the blood of the fœtus is circulating, may be brought into the most intimate contact possible with the larger but every where excessively thin-walled canals in which the blood of the mother is flowing, that the two currents, without interfering with each other's motion, may pass each other to as great an extent as may be with nothing interposed but the delicate parietes of each set of vessels; that they may exert an influence one upon another, the blood of the mother abstracting matter from that of the fœtus, and the blood of the fœtus taking, in its turn, matter from that of the mother.‡ From this description, it is evident that nothing like a true glandular structure is discernible in the placenta, which consists entirely of vessels connected with cellular tissue of which the decidua and chorion are composed, and therefore it must be included among the sanguineo-vascular ganglia.

* See his *Anatomy of the Thymus Gland.*

† See his *Elements of Physiology*, translated by R. Willis, M.D., p. 199.

‡ See Weber's *Communication* to Wagner, in his Work just cited, p. 200.

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Zoology.

b. The *Lymphatic* or *Lymph-vessel Glands*, Weber; or *Lymphatico-vascular Ganglia*, Müller.

This class of organs exists in man and in beasts some few also occur in birds, but in no other animals They are permanent through life, and belong to the absorbent system, in both its divisions, viz., the chyle as well as the lymph-vessels. Their form is generally flattish, oval, from a line to an inch in length, but less wide; the smallest only are globular, and about so large as a pea. They are usually embedded in fat, are sometimes disposed singly, at other times are distinct, but numerous, as in the mesentery, in the groins and armpits, and sometimes in masses, as when forming the Asellian pancreas in the mesentery. They are contained in thin transparent fibrous capsules, through which their greyish, or brownish-red, or black colour, is visible. Lauth says that these capsules are only seemingly fibrous, but that they are in reality made up of a net-work of blood-vessels connected by cellular tissue.* Their proper substance consists of ramifications of the absorbent vessels, which, as they divide and enter, are called *inferent*, and as, at the opposite extremity, they collect and leave the gland, are termed *efferent vessels*. Their size is much larger than that of their accompanying blood-vessels, which are quite as small as those on the mucous membrane of the intestines. Cells are described as existing in these glands; these Lauth holds to be no more than partial dilatations of the absorbent vessels; and Weber says, "it is not yet determined whether these thicker lymph-vessels have any cell-like appendages, or whether they are merely coiled up canals, but it is much more probable that the very minute, though numerous and close set blood-vessels surround them with a net-work, and thus here upon the wide lymph-vessels correspond with their disposition on the wide excretory ducts of those glands which are furnished with such ducts." It is believed that these glands operate some change upon the fluids, either lymph or chyle passing through them, but in what their change consists is unknown.

### II. Of the *Secerning Glands* or *True Glands*.

True glands are characterized by two circumstances, first, they operate upon the blood, and produce from it fluids which, generally speaking, are not found in the circulating mass; and secondly, they are furnished with ducts or tubes by which such fluids are conveyed either to the surface of the body or into its cavities. Hence is it naturally inferred, that they are bodies of peculiar organization, and that as one gland secretes bile, another spittle or saliva, and another urine, so each has its own distinct and special structure, which an examination of them severally will show to be the case.

The first step towards the discovery of the structure of glands and their excretory ducts is to be found in Bellini's paper *De Structura Renum*, 1664, in which he denied the then common opinion that the kidneys were made up of a hard, solid, fleshy substance, without any or at least with very few fibres, and proved that, "in whatever part a section of the kidney was made, fibres or filaments were distinctly seen passing from the external surface to the very cavity of the pelvis." and that "these were not muscles, but passages and canals,"† from which, when pressed, urine escaped, "as from so many little siphons: hence it may be distinctly inferred, that the substance of the kidney, up to that period called parenchyma, was nothing else than a mass of small canals and capillary passages, through which the urine passed into the pelvis." He considered that the blood penetrated to the very surface of the kidney by the most minute branches of the arteries: "but here their open mouths, not mutually anastomosing with the veins, (as fluid injected into them was discharged on the surface of the kidney,) it was necessary that the blood should flow from the vessels into a small space, which although not sensibly perceptible, yet both reasoning persuaded, and the microscope distinctly proved, might be found. In this same space, both the capillary emulgent veins, and the renal duct just mentioned, terminated. Thus, when the blood had passed from the arteries, it met with two orders of vessels, one venous, the other renal: the serum, separated from the blood, entered the renal ducts, and the blood, deprived of its serum; passed into the veins. This secretion was effected not by attraction, not by intimate connection, nor by sympathy, but by the configuration of the vessels alone and entirely,"* and the entrance of the fluid he compared to capillary attraction.

The glandular structure of the liver was described two years after by Malpighi, who, having examined it with the microscope in the simple form presented by that of the snail, speaks of it as consisting of numerous lobules of a conical rather than a spherical form, "each of which, like bunches of grapes, consists of a few conglobated, roundish bodies like grape-stones, connected with the entire lobe by means of vessels."† To these little bodies he gave the name *acini*, and after tracing them through several animals, at last examined them in the human subject. Here he found the lobules surrounded with a proper membrane, and firmly united by transverse membranous connections. "The glandular acini composing the lobules" have, from their circumscription, a regular hexagonal or many-sided form, and each, the very smallest lobule, is supplied with numerous branches of vessels." And though the very extreme branches of the blood-vessels and biliary pores cannot be seen terminating in the glandular acini, yet as "the entire mass of the liver is made up of the glandular acini and the several vascular trunks, and some common operation mutually springs from these, there must be a communion between the glands and the vessels." And he concludes, "the glandular acini, with which the mass of the liver is beset, are interposed between the afferent (or blood-vessels) and the efferent (or biliary) vessels." In 1688, after many years of silence, as he observes in his letter to the Royal Society, Malpighi resumed his observations on the glands. He there states that "the glands freely distributed on the palate, gullet, intestine, &c. are of the most simple form, and the type of the other glands, consisting each of a membranous follicle or chamber, oval, round, lenticular, or oblong, provided with a cavity, which mostly opens into an excretory vessel, by which the secreted humour is poured into some special recipient, or at once discharged; and that around this chamber or follicle, blood-vessels

* See his *Nouveau Manuel de l'Anatomiste*, p. 600.
† See Bellini, *loc. cit.* p. 19, *et infra*.

* See Bellini, *loc. cit.* p. 23.
† See his *Epistolæ Anatomicæ*, p. 59, *et infra*.

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and nerves are distributed.* Further on he observes, "As to the conglobate glands, hitherto examined, nature seems to pursue one and the same plan, since to the excretory vessel she attaches one, sometimes more follicles or membranous acini, by means of which vessels she separates the peculiar humour and pours it out. I have elsewhere noticed that nature employs the same proceeding in the formation of the viscera, (observing that the liver, brain, and renal glands, together with the mammæ, testes, and other similar parts, may be hereto added,) as proved by the copious mass of follicles attached to the excretory vessels."† And he then states that the glandular follicles (as he calls them) "of the liver are so many cœcal intestinules made up of glandular membrane, because in the Pancreas, of which no one doubts the glandular structure, it is ascertained that nature forms follicles round, sometimes oval, not unfrequently oblong, and resembling cœca, which are employed as the organs of secretion." From this brief account, it may be presumed that the *spatiola*, or little spaces into which the blood was said to be poured out by Bellini, in order to allow the commencement of his renal ducts to abstract the urine, correspond with the *acini* spoken of by Malpighi. In the following century, Ruysch, who was celebrated for the minuteness of his injections, distinctly denied the existence of Malpighi's *acini*, and a violent dispute upon this point took place, some anatomists holding with one, and some with the other statement. Ruysch says that the *acini*, both in simple and conglobate glands, are *little masses or heaps of vessels* interwoven, and involved with each other, and he supposed that the vessels proceeded uninterruptedly into the duct, and therefore that the duct could be considered merely as an elongated blood-vessel. Haller seems to have leant, if not indeed to have agreed with Ruysch's opinion, but not from ocular proof; for he observes, "ducts of this kind can scarcely be proved, by the testimony of our senses, to be continued from arteries. Leeuwenhoek never, with his microscopes, saw any radicle of an excretory duct arise from an artery, nor has any one from that time been more fortunate in discovering their origin."‡ Haller's opinion is founded upon the circumstance of fluids passing from injected arteries into excretory ducts. But this explanation is upset by Müller's statement, that the passage of fluid from one vessel to the other is in consequence of rupture, the extreme branches of the duct in these cases not being injected. Haller, however, appears very nearly to have hit upon the true elementary glandular structure, for he elsewhere observes, "the *acini* found in the viscera of animals are compound lobules, not elementary parts," and that "the real elements of all glands are small white cylindrical vessels."§ The discovery of the true secretory structure of glands is assigned by Müller to Ferrein, who, in his Essay *Sur la Structure des Viscères nommés Glanduleux, et particulièrement sur celle des Reins et du Foie*, opposing the opinions of both Malpighi and Ruysch, says, "I do not hesitate to assert that the cortical part of the kidney, the spleen, the liver, and many other parts, are made up of neither blood-vessels nor glands. I have found that they are formed of a substance peculiar to them, and neither resolvable into arteries and veins, as Ruysch has pretended to show, but distinctly the contrary; and I have also observed that neither is the substance composed of glands, said to have been seen by Malpighi, and so many other anatomists; in short, I assert that these parts are a wonderful assemblage of tubes, white, cylindrical, variously coiled, which I show distinctly in the kidney, and which I have seen, if I mistake not, in the liver, in the atrabiliary capsules, and which I believe may be recognized in other viscera."* Ferrein did not, as might be inferred from Müller's account, discover this peculiar structure by injecting from the duct itself, as was subsequently done, but he states, "I have examined these different organs, (the liver, spleen, &c.) when their red colour (communicated by the blood) was most decided; I made use of the aid of lenzes and of the microscope. I have constantly found in all these parts a white, slightly transparent substance, almost like jelly, and without the least tinge of red;" and further, "I filled the arteries and veins with injection not less penetrating I believe than that of Ruysch; the white colour of this substance, however, did not undergo the least change." He appears to have been dissatisfied with the theories previously held, and, on making examination, discovered in the cortical substance of the kidney, and in the liver of children of five or six years, an immense number of particles, white in the kidney, yellowish in the liver, some irregularly round, at least in appearance, others oblong, but of extreme delicacy. The actual discovery of the vessels he thus describes: "I accidentally examined a human liver, the colour and consistence of which sufficiently marked its derangement; what was my astonishment, when these minute parts presented themselves in shape of rings or half rings, apparently formed by the inflection of an extremely delicate thread or white vessel, which seemed to produce successively many similar figures. Astonished at so remarkable a structure, but which did not appear sufficiently distinct, I examined a great many other livers; I found more than one, and particularly that of a child of six years, in which I perceived the same objects, the same inflections, but never with that degree of sharpness which produced perfect and entire conviction."† On examining the kidneys of aged persons he was still more fortunate, and "saw, as decidedly and distinctly as possible, a wonderful assemblage of little white tubes, moderately transparent, folded in rings, half-rings, rosettes, and a thousand other ways; these tubes, perfectly distinct from the blood-vessels, formed the whole cortical substance of the kidney." The round or oblong particles which he at first noticed, he satisfied himself were merely the prominent points of the inflections of these vessels, which he called the *white cortical tubes*. This cortical or external part of every kidney incloses the interior substance, called medullary or fibrous, which has a more or less globular form, and terminates in a papilla, which protrudes into a calyx or branch of the pelvis of the kidney. Ferrein's inquiries proved that Bellini's statement of the "fibres or filaments passing from the surface to the very cavity of the pelvis of the kidney," was correct; and he showed that these Bellinian tubes, as they were called, when making up the medullary substance of the kidney, could be traced

* See his *Epistola de Structura Glandularum conglobatarum consimiliumque partium*, p. 2.
† See *Ib. loc. cit.* p. 20.
‡ See his *Elementa Physiologiæ*, vol. i. p. 96.
§ See his *Primæ Lineæ Physiologiæ*.

* See *Mémoires de l'Acad. Roy. des Sciences*, 1749, p. 491.
† See *Ib. loc. cit.* p. 497.

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as "an infinity of little prolongations of a cylindrical shape, and one-fifth of a line in diameter," passing from the medullary into the cortical part to within half a line of its external surface, which were "evidently a continuation of the fibres, true or false, of the medullary body."* Ferrein denies, however, that these so-called Bellinian tubes are simple excretory ducts, as described by that writer, and by Malpighi, and he says that the apertures in the papillæ which they describe as belonging to the tubes, are not so, but merely the openings of cæcal tubes, which do not extend above the papillæ. He states that in the kidneys of persons fifty years old, he "saw distinctly that the tracks or seeming fibres which, in the kidneys, had appeared either with the naked eye or with the aid of glasses, simple, really consisted of *bundles, each composed of a very great number of vessels, some red and others white*; all extremely delicate, but quite distinct and unconnected, instead of being, as in other kidneys he had examined, massed together, and forming the fibres or pretended tubes of Bellini."† The red vessels, he says, are the blood-vessels, which Ruysch and others considered as urinary tubes, formed by the continuation of arterial branches. "The white tubes which I also observed in great numbers in each bundle are the true excretory, urinous tubes, *very different not only from those of Ruysch, but also from those of Bellini*."‡ "They are completely cylindrical, decidedly never have their diameter diminished in passing from the circumference of each kidney towards its papilla, and are of remarkable delicacy, although much larger than the white cortical tubes." They take an undulating course from the circumference of the medullary globe towards the papilla, where they seem to straighten; some, however, in twos or threes, do not straighten, but are inflected numerously upon themselves, forming not exactly granules, but little masses, after which they stretch out in an undulating manner into the papilla. These he distinguishes as the *serpentine, medullary, new urinary tubes*. Numbers of them are found in the cortical substance extending to its surface, and contained in a sort of chambers, but still formed of red and white, or blood and urinary vessels. From the white cortical tubes they are easily distinguishable, by their disposition, duration, greater size, diminished whiteness, and dry and somewhat shrivelled appearance. The origin of these serpentine tubes is very difficult to be discovered, as they are almost always hidden by the cortical tubes, which form prominent tufts. "I have, however," says Ferrein, "perceived towards the bottom and sides of the cortical chambers some serpentine vessels, which seemed to implant themselves into the cortical tubes. It is then quite certain that they do not come from the pretended glands of Malpighi and others, nor from the blood-vessels which Ruysch, Boerhaave, and their followers have taken for urinary tubes." And although the seeming medullary fibres, or Bellinian tubes, diminish in size as they approach the papillæ, "it is never so with the serpentine tubes which enter into their composition; I am well convinced that they lose none of their diameter; it seems to me, after many inquiries, that the diameter is rather more considerable near the papilla." It has been necessary to enter thus fully into Ferrein's account of his discovery, that the Bellinian canals or ducts, or fibres, are not simple, but that they consist of

* See *Memoires de l'Acad. Roy. des Sciences*, 1749, p. 502.
† *Ib.* p. 507. ‡ *Ib.* p. 510.



two kinds of vessels, to wit blood-vessels and urine vessels, because Müller has appropriated it to himself; and Huschke says that "th straight tubes passing from the surface of the kidney .o the papillæ are arteries and veins," which, instead of becoming wider as the urinary tubes do, become much more delicate, and form the usual vascular net-work around the apertures of the urinary tubes."* Ferrein, however, does not speak of any straight tubes, but of serpentine tubes which have their diameter never diminished, but, on the contrary, seemed to have it increased as they approach the papilla, and are throughout surrounded with blood-vessels. Müller really adds nothing to what had been previously advanced by Ferrein, who, describing his serpentine vessels, says that they are neither derived from the so called Malpighian glands, nor from the blood-vessels as stated by Ruysch; and, as he says, that they are freely accompanied with blood-vessels, and in the cortical chambers passed off at their sides and bottom into the cortical tubes themselves, it may be inferred that he considers the urinary secretion is effected both by the arteries and by the cortical white tubes, and, therefore that little, if any, more is advanced by Müller's statement, that "the origins or springs of the secretion of urine are the inflected urinary canals themselves, which not merely at their extremities, but throughout their entire and extensive surface, produced by their inflexions, separate those parts of the blood which are to be converted into urine."† It may be here added that Huschke has ascertained by injection of the emulgent or renal artery that the *acini* of Malpighi are merely coils of arteries, whence are produced the vascular net-work overspreading the most delicate urinary tubes, described by Eysenhardt, and doubtless the same as that mentioned by Bellini.

From what has been mentioned, it appears then that some glands are tubes with vessels ramifying upon them and pouring in their peculiar secretion; that these tubes may be simple follicles or cæcal bags, like the finger of a glove, of which the sebaceous follicles or glands in the skin, the mucous follicles of the alimentary canal, the pancreatic follicles of many fishes, and the biliary follicles of many insects, furnish good examples. Whilst the urinous tubes of the kidney in the human subject, and in many other animals, and the seminal tubes in many classes of animals, exhibit the same tubular character, but of great length, and largely convoluted. Other glands are made up of branching tubes, such are the lachrymal gland, the mammary and salivary glands, the pancreas and the liver in the higher orders of animals: the only real difference, however, between the two kinds is, that whilst in the so-called tubular form, the secreting vessel forms a single tube, in the other a principal tube is formed, which sends out or receives on its sides short processes like twigs of trees, upon which also a vascular net-work for secretion is outspread.

### Of the Erectile Tissue.

*Tela Erectilis*, Lat.; *das erectile oder schwellbare Gewebe*, Germ.; *le Tissu Erectile*, Fr.

This tissue, soft and flaccid in its quiescent state, is capable under excitement of distension with blood, and thereby erecting and stiffening the organs in which it exists, on which account it received from Dupuytren the name of Erectile Tissue. It is distinguished from

* See Müller, *loc. cit.* p. 434. † See p. 434.



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Zoology.

Glandular Tissue, to which also under excitement larger quantities of blood than necessary for the mere autrition of the part are sent, by the blood it receives not undergoing any change, but being simply retained in the tissue during such time as is sufficient for the performance of the function to which the erection of the organ is an adjunct. Erectile Tissue exists especially in the penis and clitoris, of which indeed it forms the principal component; the prominence of the nipple is also considered to depend on the distension of this tissue which it is believed to contain, but it does not seem absolutely necessary to call in this tissue to account for its erection, as the simple distension of the milk-tubes is amply sufficient to produce such a result. The combs and wattles of poultry are also said to be made up of this tissue.

The inquiries of anatomists in reference to the nature and character of Elastic Tissue have been principally directed to the examination of the penis and elitoris, in which it is most largely developed, contained within fibrous sheaths, the purport of which seems principally to be that of restricting the distension of the tissue within certain bounds. It was formerly held that the fibrous sheaths of the penis contained different structures: in the one sheath there was said to be a cavernous or cellular, and in the other a spongy substance, and thence arose the distinction into the cavernous and spongy bodies of the penis. Even Mr. Hunter distinguishes the two, for he says, "the cells of the *corpora cavernosa* are muscular," and "the *corpus spongiosum*, urethra, and glans penis, are not spongy or cellular."* Modern anatomists, however, consider the composition of both as similar, and such is also the opinion of Müller† and Valentin,‡ by whom the best accounts of the tissue in this organ have been given.

From the interior surface of the fibrous sheath, bundles of fibres, to which the term "pillars" has been applied, pass transversely inwards towards the middle, giving off in their course smaller and smaller threads; and, uniting with corresponding small threads and larger fibres from the opposite sides, a network is formed, the mesh-like spaces between which are the cells of the older writers, and the "plexus of veins," of which Mr. Hunter says the spongy body is made up. Valentin speaks of seemingly muscular longitudinal fibres observed on making an incision lengthways of the cavernous bodies in the horse and ass; this corresponds with Mr. Hunter's statement of the muscularity of the cells in those parts, but he says that closer inspection shows them to be merely the walls of the spaces themselves. Microscopic examination of the fibres or pillars forming the mesh-like spaces shows them to be of a flattened or rounded form. Each is enveloped with a simple transparent epithelium similar to that lining the interior surface of veins, beneath which is a very thin layer of delicate venous fibres intermixed with cellular tissue; next follows elastic tissue, to which succeeds a thick layer of simple fibres collected into large bundles, corresponding with those of the middle coat of an intestine, or, in other words, organic muscular fibres; within this layer, one or several tendinous bundles are seen intermingling with each other, some visible to the naked eye and others requiring the aid of a lens, and in the central interspace between these is found an artery, which is much convoluted and ramifies in correspondence with the branchings of the pillars, each ramification however still exhibiting the same tortuous character. The fibres or pillars thus exhibiting the several structures existing in venous tubes, there can be no doubt that they are the walls, as the mesh-like spaces are the cavities, of the venous plexuses, making up the principal part of the mass of the penis; whilst the arteries found in the centres of the several fibres, which ramify and diminish correspondingly as do the fibres, in reality only pass in the interspaces left between the branches of the veins massed together and forming the plexus.

Müller considers that the Arteries in the penis are divided into two sets, one set for nutrition, and the other to produce erection; and that although both are derived from the deep artery of the penis, yet they "are distinguished from each other, as well by their size as by their course, form, and object." The Nutrient Arteries are as minute as in any other parts of the body, anastomose, and are distributed on the pillars of the spongy substance till they cease to be perceptible. The other class of arterial branches are "short, about a line long and one-fifth of a millimetre thick, and are given off from the larger as well as from the smaller branches of the deep artery, generally at a right angle, as fine branches, though still discernible to the naked eye, which project into the cavities of the spongy substance, and either terminate abruptly or expand into a club-shaped form without giving off any branches." In the human subject Müller describes "these branches as stretching away from place to place, sometimes singly and sometimes in little bundles, whereby small tassels, consisting of from three to ten arterial twigs, are formed, which regularly protrude into the cells or venous cavities of the cavernous bodies. . . . . . . Almost all these arterial branches are remarkable for their extremity being curved like a horn, so that it describes half or more than half of a circle. And if such branch divides dichotomously, its two twigs curve towards each other." From the resemblance of these arteries to the tendrils of the vine Müller has called them "Helicine." He says also, that neither upon their extremity nor on their surface are any apertures distinguishable by the microscope, and that if the blood, as is probable, in erection passes from them in larger quantities into the cells of the cavernous bodies of the penis, this must be effected through invisible openings, or at least by openings which first increase in size by the greater expansion of these arteries." And he presumes that, though under ordinary circumstances, the blood passes through the nutrient arteries alone, and not through the helicine, and thus only in small quantity by the commencement of the veins into the cells, yet during erection, it probably is poured through the helicine arteries in considerable quantity into the cells.

The existence of helicine arteries is denied by Valentin, who says that "the so called helicine arteries of the penis are by no means peculiar, blind-ended, loosely projecting into the mesh-like spaces of the cavernous bodies, but simply cut or torn small arteries; and that, on the contrary, the true arterial ramifications in the cavernous bodies invariably follow the most simple laws." His reasons for these opinions are detailed in the able paper already referred to.

* See his *Observations on certain parts of the Animal Œconomy*, p. 43.

† See Muller's *Archiv* for 1835, p. 202. His paper, *Entdeckung der bei der Erection des männlichen Gliedes wirksamen Arterien*, &c.

‡ See ib. for 1838, p. 182. His paper, *Ueber den Verlauf der Blutgefässe in dem Penis des Menschen*, &c.

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# ZOOLOGY.

## SECTION II.

### DESCRIPTION AND COMPARISON OF THE ORGANS IN THE SEVERAL CLASSES OF ANIMALS, OR ZOOTOMY AND COMPARATIVE ANATOMY.



To examine the structure of an Animal with the view of ascertaining the mode in which the tissues already described are built up into Organs requisite for the support of its own existence, and for the continuance of its kind, is the province of Zootomy or Dissection. To compare the modifications of Organs, by which in the several Classes of Animals the same functions are performed, is the still more important object of Comparative Anatomy.

In entering upon the study of these subjects, which to be of any practical advantage must be carried on simultaneously, the inquirer is in difficulty as to the Organs which should be first made the objects of his attention. But as the Motive Organs are peculiar to Animals, and are at once recognizable by their actions, and often specially so from their size; and as their form and disposition most commonly indicate the habits of an animal, and are external signs of its internal structure, they seem to claim the first attention of the student, and for that reason will now be considered.

#### Of the Motive Organs in general.

The Motive Organs are of two kinds, passive and active, 1st. the machine to be moved, consisting of skin and its modifications, horn and shell, or bones; and, 2nd. the moving powers or muscles by which it is to be moved. In the large division of animals which form the Invertebrate Series, so called from the absence of any peculiar chamber and canal for their great nervous centres, the muscles are attached to the interior of their external covering, be it skin, as in the *Slug*; horn, as in the *Beetles*, or calcareous crust, as in the *Lobster*. Such were formerly but very improperly called external skeletons. On the contrary, in the Vertebrate Series, of which the nervous centres are specially separated from all other parts by inclosure in a chamber and canal composed of cartilage or bone, the muscles are placed upon the exterior of the cartilaginous or bony organs, which form a frame-work or skeleton for the support of the soft parts, give a well marked figure to the animal, and furnish a series of levers so connected, that, being acted upon by the muscles attached to them, they convey the trunk from place to place, and vary the position of different parts of the body in regard to itself as the animal wants may need.

#### Of the Motive Organs in the Invertebrate Series of Animals.

The Motive Organs in this Series present great variety of structure, form, and arrangement, varying from the soft jelly-like character of the Polyps, through the coarse leathery skin of the *Ascidiæ*, and the horny covering of Insects, to the calcareous coverings of the Crustaceans, in all of which the external case of the animal serves at the same time both as a protection to its soft parts and also as the levers by which it is moved.

Zoology.

The following six Classes are included by Cuvier in the lowest great division of the Animal Kingdom to which he applies the name ZOOPHYTES, or RADIATED ANIMALS, from their parts being disposed around an axis; but he at the same time observes, that neither designation is to be taken in its extreme sense, as many genera do not exhibit any radiating form, and, excepting the Polyps, none have any resemblance to plants.

#### Sponges.

Notwithstanding the various inquiries which have been made in regard to the Class of Sponges, but little is known as to their true nature, beyond the anastomosing horny filaments of which their frame-work consists, and which, whilst the Sponge remains alive in water, is overspread with a thin layer of glairy semifluid matter. In many instances the elasticity observed in the Common Sponge does not exist, an unyieldingness being imparted to the mass by the deposition in its interior of chrystallized spicula of various form, consisting of calcareous or siliceous matter, corresponding in shape to the *raphides* observed in vegetable structures, and which exhibit determinate forms in different species. The whole surface of the Sponge is studded with innumerable and minute apertures which lead to canals in its interior, and these, gradually coalescing and forming larger and larger passages, terminate in cavities which open by large and commonly projecting orifices upon the surface of the Sponge. Through the minute orifices the water is absorbed into the Sponge, and is poured out of it in continuous streams by the large apertures. Locomotion does not belong to the Sponges; they are permanently fixed, excepting at their first production, when, according to Dr. Grant's statement, the gemmules from which they are generated are furnished with cilia, and capable of moving about in the water till they have selected a spot, where they attach themselves and remain throughout the rest of their existence.

#### Polyps.

Although in the living film which overspreads the Sponges, no distinct animal form can be observed, yet in that which enveloped the several kinds of marine productions, commonly known as Madrepores, Corals, &c., and which have either a cartilaginous, horny, or calcareous substance, distinct animal forms are seen, of a jelly-like, semitransparent nature, cylindrical in form, with an intestinal cavity having a mouth surrounded by many lengthy processes or arms, (whence their name Polyps,) and their opposite extremity or foot attached to the cavities in which they reside. The whole animal is capable of motion, by the expansion and contraction either of parts or the whole of its entire mass, and thus can project itself to a certain extent out of its chamber, expand its arms or tentacules, and sway both them and its cylindrical body in all directions so as to bring it in con-



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tact with the prey it desires to seize, around which it throws its arms, and clasping them conveys it to its mouth. The cavities in which these Polyps live are called *Polyparies*, which are either sunk in a mass of fleshy substance overspreading the axis or solid stem supporting and giving form to the whole animal structure, as in the *Alcyonida* and *Corallida*, which are therefore called *Cortical Polyparies*; or a quantity of earthy matter is deposited in this encrusting mass, and more or less solid cavities produced in which the Polyps reside, and these being hot shallow cells, such Polyparies are called *Cellular*, good examples of which are presented in the *Cellepora* and *Flustræ*. If, however, the cells increase in depth, and form long tubes, as they do in the *Tubipora Musica* or Organ Coral, such are called *Tubular Polyparies*. All the Polyparies just mentioned are fixed, that is, their stems are attached by broad bases or roots to some stone, rock, or other substance proportioned to their size. But there are some which, although residing in a common fleshy substance overspreading a solid axis, are unattached, that is, the whole mass floats loosely in the water, as the *Pennatulæ* or Sea-pens, which are by some writers believed to be sculled about by the polyps contained in them. Some of the Polyps, however, are not contained in or attached to any polypary cavity, but are naked, gelatinous, independent animals, moving about at their own pleasure, and are called *Naked Polyps*, of which the Green Polyp, *Hydra viridis*, so well known from the papers of Trembley, furnishes a good example. The several kinds of Sea Anemones, *Actiniæ*, are considered to belong to the Polyps, of which they form the *Fleshy Order*; their shape is that of a short hollow cylinder, highly contractile, the bottom or foot of which is capable of fixing itself very firmly; its sides are also contractile, and have a coriaceous consistence; a wide aperture on the upper surface leads to the large stomach, which occupies the central part of the coriaceous cylinder, between the mouth and the upper edge of the cylinder an immense number of tentacules are ranged in a circular form, which can either be outspread like the petals of a flower, or retracted so as to be scarcely visible. These are the organs of prehension, but they have also much more important functions.

### Infusories.

This Division of the Animal kingdom, formerly considered by microscopic observers as exhibiting the most simple forms of animal life, has of late years been shown, by the observations of Bory de St. Vincent, and especially of Ehrenberg,* in most instances to consist of very complicated structures, and generally to be far advanced above many animals which far exceed them in size.

They are divided by Ehrenberg into two classes, the Polygastric Class, in which the Alimentary Canal is divided into numerous cavities or stomachs, and the Rotatory Class, furnished with a remarkable organ, which in its motions appearing to resemble the turning of a wheel, is called the Wheel organ. The latter class is more advanced in the scale of development than the former, but it is convenient to consider them together, especially as they present many points in common as regards their covering and motive organs.

*External Covering.*—In both Polygastric and Rotatory Classes some kinds have no special covering, such are called by Ehrenberg, naked, *nuda*; whilst others, inclosed in a sort of armour, *lorica*, he calls covered, *loricata*. Of this covering or armour he describes five kinds.

1. The Shell, *testa, testula*, a firm skin, often furnished with little teeth, horns, spines, points, or warts, in which the animal lives like a tortoise within its shell, the head and tail only projecting. Usually in the Loricated Rotatory Infusories it is depressed, as in *Brachionus amphiceros*, (Infus. Pl. 2, fig. 33,) but sometimes compressed, and resembling a bivalve shell, for which it has been often mistaken, as in *Colurus caudatus*, (Pl. 2, fig. 26,) and occasionally of a quadrangular prismatic shape, as in *Salpina*. 2. The Target, *scutellum, scutellulum*, seems to be peculiar to the Polygastric Class: it is firm, round, or oval, smooth edged, and only covering the back of the animal, as in *Aspidisca denticulata* (Pl. 1, fig. 60) and *Euplotes Charon*. (Pl. 2, fig. 7). 3. The Pitcher, *urceolus*, is a membranous or firm covering, often cartilaginous, bell-shaped, cylindrical, or conical, closed at bottom, open and expanded in front, within which the animal can either retract entirely, or project itself from it: examples are presented among the Polygastric Class, in *Difflugia proteiformis*, *Vaginicola chrystallina*, (Pl. 1, fig. 22 and 48,) also among the Rotatory Class, in *Floscularia ornata*. (Pl. 2, fig. 16.) Sometimes, as in *Ophrydium versatile*, (Pl. 2, fig. 46,) a number of these little pitchers are heaped together, so that a mass far exceeding the size of the animals is produced. 4. The Cloak or Mantle, *lacerna*, which exists only in the Polygastric Class, is a thick gelatinous mass or skin, apparently the external layer of the animal itself, expanding with age, and under the protection of which, the internal parts of the body freely divide, according to certain normal proportions, and inclose other individuals which become loose upon the surface of the parent. After a time this membrane loses its individuality, becomes subservient to the wants and will of the internal brood, and performs to them the office of a tegumentary covering, as in *Volvox globator*. (Pl. 1, fig. 12.) 5. The Bivalve Target, *lorica bivalvis*, exists only in the large family *Bacillaria*, is of a quadrangular prismatic form, of a siliceous nature, and when dry splits into two or more pieces, as in *Navicula phœnicentron* and *Bacillaria vulgaris* (fig. 28 and 29.)

In most of the Infusories, a head, trunk, and tail are distinguishable. 1. In the Polygastric class the Head is scarcely discernible, but in the Rotatory it is readily distinguished, forms the anterior part of the body, and supports the wheel organ, eyes, mouth, and masticating organs; in it also is the great nervous ganglion, which Ehrenberg presumes to be the cerebral. The mouth is generally placed beneath, and not precisely at the anterior extremity, which is formed by the projection of the forehead, distinguished by the red eye-spots, and often also stretches like a proboscis beyond the wheel organ, as in *Rotifer macrurus* and *Philodina aculeata*, (Pl. 2, figs. 29 and 30,) or drops into the anterior upper edge of that organ, as in *Furcularia gibba* and *Diglena grandis*. (fig. 20 and 21.) Sometimes, as in *Brachionus amphiceros*, (Pl. 2, fig. 33,) the forehead is divided into three lobes, covered with little hairy styles. In *Rotifer* the eyes stand far forwards on the proboscis, but in *Philodina*, on the contrary, they are backwards above and behind the mouth. Sometimes the nape of the neck is indicated by a narrowing, but more commonly by the base of the wheel organ or by the position of the eyes

* See his paper *Ueber die Entwickelung und Lebensdauer der Infusionsthiere* in the *Abhandl. der Akad. der Wiss. zu Berlin*, 1831.

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Zoology. The mouth is often provided with a pair of lips, which may be seen in both the POLYGASTRIC and ROTATORY Classes, as in *Chilomonas volvox*, *Euglena viridis*, (Pl. 1, figs. 5 and 17.) and in *Melicerta ringens*. (Pl. 2, fig. 17.) In the POLYGASTRIC Class, as in *Lachrymaria proteus*, (Pl. 1, fig. 50,) the neck is very distinct, a long gullet passing from the mouth to the stomach; but it is scarcely if at all discernible in the ROTATORY Infusories. 2. In the POLYGASTRIC Class the Trunk is less readily distinguished than in the ROTATORY, where it begins behind the base of the wheel organ, but its dorsal and abdominal surfaces are readily distinguished by the apertures of the mouth and vent being on the latter. The genera *Enchelys*, *Coleps*, (Pl. 1, figs. 49 and 53,) and *Actinophrys*, are exceptions, as their mouth and vent are in the very centre of their extremities, and the absence of eyes affords no other guide. 3. The Tail is all that part of the animal beyond the vent, and may be compared to the foot of Molluscs. In the POLYGASTRIC Class it is most simple, as in *Astasia hæmatodes* and *Amphileptus fasciola*. (Pl. 1. figs. 16 and 59.) In the *Vorticellinæ* a long process is sent out, on the tip of which is a sucker. Its simplest form, in the ROTATORY Class, is a mere lengthening of the soft body from the abdominal surface, with a sucking cup, *patella*, at its extremity, by means of which it can fix itself, as in *Glenophora trochus* and *Pterodina patina*, (Pl. 2, figs. 11 and 34;) sometimes a long stiff shank supports the sucking cup, as in *Monura*, *Monocerca*, &c.; but the greater number of this Class have the tail bifurcated, as in *Ichthydium podura*, *Chætonotus maximus*, (Pl. 2, figs. 9 and 10,) &c., and in the genera *Furcularia*, *Euclanis*, (Pl. 2, figs. 20 and 25,) and *Scaridium*, these forked processes are of considerable length. In the genus *Actinurus*, and one species of *Dinocharis*, the tail is trifid. All these animals make use of these organs as a pair of forceps to seize the food which has been brought within their reach by the currents produced by their wheel organs. In *Rotifer*, *Philodina*, and some others, the tail is capable of retraction within itself like the joints of a telescope; and such are often armed with little horny points, sometimes in pairs, as in *Rotifera*, sometimes in triplets, as in *Philodina*.

*Motive Organs.*—The Organs of Motion in Infusory Animals are either simple or compound.

The most remarkable of the Simple Motive Organs are the Changeable Processes, *processus variabiles*, which belong entirely to the POLYGASTRIC Class, and result from the power which those animals possess, of protruding at pleasure parts of their body into variously shaped lobes and long tubes, at one or many points at the same time or alternately, and hence arise the protean changes for which many Infusories were so celebrated, but of which the cause was not known till discovered by Ehrenberg. According to his observation this change of form depends upon the animal relaxing the part to be protruded, and then, by the contraction of the rest, thrusting the stomach and its contents against the relaxed part and projecting it in a finger or foot-like form, just as a hernial sac is produced by the intestine being protruded from the belly. In this way is it that all parts of the *Amœbæ* (Pl. 1, fig. 21) can be thrust out into processes. But in the *Arcellinæ* the projections can only be formed on the fore part of the body and by the propulsion of a transparent fluid, not, as in the former case, of the alimentary canal. The *Bacillariæ* have also this remarkable property. This power of changing form and thrusting out processes is well adapted for pushing the animal along, in much the same way as a boat is pushed by a pole. In many Infusories, stiff, straight, and long Bristles, *setæ*, are observed, implanted in the animal substance, and are capable of slow elevation and depression. The Hairlets, *ciliæ*, by which the turnings about of the Infusories are effected, are distinguished from the bristles, by their bulb-shaped base, which moving slowly upon their seat by means of a pair of muscles, produce extensive circular swinging of their point; this can be well observed in the larger species of *Stylonychia* and *Kerona*. In the Polygastric Infusories they are often spread over the whole body, and are arranged in distinct rows, generally longitudinal but sometimes transverse; sometimes they exist only about the mouth, and in the ROTATORY Class on no part except on the wheel organs. The whole body is only covered with these cilia in the Naked Infusories, with one solitary exception, the genus *Coleps*, (Pl. 1, fig. 53,) the armour of which consists of numerous little pieces placed in rows, and the interspaces studded with cilia. Hooklets, *uncini*, are sometimes observed, either ranged upon the abdominal surface, as in *Stylonychia* and *Euplotes*, and serving as feet or claws, or occupying the place of an upper lip, as in *Glaucoma*, *Colurus*, and *Scaridium*. Thick, straight, and very movable bristles, called Styles, *styli*, exist in both Classes of Infusories, having a distinct articular connection with the surface of the body; they are very distinct in *Oxytricha cicada* and *Stylonychia pustulata* (Pl. 2, figs. 3 and 4) upon the hind part of the body, and seem to be employed for feeling. In some of the ROTATORY Class they also occur, and if upon the wheel organ or on the forehead, they remain outstretched and quiescent during the action of the former.

Compound Motive Organs belong specially to the ROTATORY Class of Infusory Animals, of which they constitute one of the most remarkable characters. They are formed by the collection and arrangement of numerous *cilia* or hairlets, about the front of the body, which turning or moving upon their base independently of each other, produce an appearance so closely simulating that of a wheel turning upon its axle, as to have led the Microscopist Baker to describe them as actually so formed, and hence has been applied to them the name of *Wheel Organs*. The impossibility, however, of the existence of a wheel and axle in an organized body naturally struck more philosophical observers, and various theories were brought forward to explain this curious phenomenon. Dutrochet believed it to depend upon the alternate contraction and relaxation of portions of a circular muscle, by means of which its periphery is kept in a state of continual undulation when the organ is in motion. From the observations, however, of Ehrenberg, there can be no doubt that the rotatory motion results from that of cilia, which differ only from other cilia in their arrangement. Each separate cilium is moved by a muscle placed beneath it, and if muscular threads pass to many or all the cilia of the same row, they are all moved in one direction; whilst, if muscular fibres are attached on the other sides of the base of the cilia, and at different heights, an oscillatory motion in four directions is produced, causing a circular motion of the tip of each cilium, whilst the whole cilium itself describes a cone, of which the apex is its base. In this way is the motion produced in the *one* and *two wheeled*, but not in the *many wheeled* animals. The Wheel

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Organs are either *Monotrochous*, *i. e.* have a simple connected ring of cilia, or the ring is divided or manifold, as in the *Sorotrochous* Infusories. In the Monotrochous section, the circle or wheel is of the most simple kind, and is placed near the mouth, which is not contained within but on one side of it, interrupting the ring, so that, instead of being circular, it has the shape of a horseshoe closely set with cilia, between the heels of which the mouth is placed. If the periphery of the wheel be regular, as in *Ptygura melicerta*, *Ichthydium podura*, (Pl. 2, figs. 8 and 9,) such Infusories are called *Holotrichous*; but if it be indented and produced here and there into lobes, as in *Microcodon clavus*, *Tubicularia najas*, and *Floscularia ornata*, (figs. 14, 15, and 16,) such are said to be *Schizotrochous*. Two subdivisions of the Sorotrochous are also observed, the two wheeled or *Zygotrochous*, in which the wheel organs are implanted on a pair of processes like arms, capable of protrusion and retraction, situated close to each other, and between the mouth and proboscis, as in *Rotifer macrurus* and *Philodina aculeata* (figs. 29 and 30). Those which have more than two wheel organs are called *Polytrochous*, such as *Hydatina brachydactyla* and *Euchlanis luna* (figs. 19 and 25.)

The use of the cilia, whether simply disposed about the mouth or forming wheel organs, is to produce a current in the water by means of which the food is brought to the mouth, and also to serve the purposes of locomotion by swimming, which in some genera, as in *Philodina*, is restricted to crawling, like leeches, prior to the development of the wheel organs.

### Acalephs or Sea-nettles.

These animals are mostly of transparent, gelatinous structure, and hence commonly known by the names *Sea-blubber* or *Jelly-fish*; or, from the stinging sensation they impart when touched, *Sea-nettles*: this property was observed by the ancients, and hence also the name ἀκαλῆφαι, applied to them by Aristotle. They are furnished with locomotive organs, are capable of translating themselves from place to place, and most of them are highly phosphorescent. The beautiful form and colours of these animals have attracted the attention of many naturalists, but the most recent and the best observations relating to them are those of Eschscholtz, Ehrenberg and Brandt, the former of whom divides them into three orders.*

1. The *Ctenophorous or Crested Order*

Is characterized by longitudinal rows of cilia or vibrating threads arranged in pairs, so as to form narrow passages, which being connected with these locomotive organs are called *ambulacra*. The form of their bodies is either a flattened spheroid, truncated at one extremity like a deep cup, so as to form the aperture leading to the large simple stomach, as in *Beroe*; (*Acaleph.* Plate, fig. 1.) or a much compressed ovoid, as in *Mnemia*, or a cylinder, with a pair of flatted wings, as in *Callianira*, (fig. 2.) or a long flat ribbon, in the middle of which is the stomach, as in the beautiful *Cestum Veneris* or Venus' Girdle (fig. 3.). In some, the mouth is provided with a pair of ciliated tentacules, which are either simple, as in *Cestum*, or branched as in *Callianira*; but in others, as in *Beroe*, no such tentacules exist.

2. The *Sciaphorous Order*.

These are distinguished from the other orders by the umbrella shape of their body, which being likened by Oken to a hat, he has therefore named them *Hutquallen*. Latreille calls them *Cyclomorphous* and Eschscholtz *Discophorous* Acalephs, but neither of these terms expresses their general actual form, except in the genera *Berenice* and *Eudora*, and are therefore inadmissible. The comparison of their body to the shape of an umbrella, commonly used by the French Naturalists, who therefore call it *ombrelle*, furnishes the best character for naming the order. The convex upper or dorsal surface of the umbrella-shaped body varies considerably: sometimes, as in *Berenice*, (fig. 4.) it is nearly flat, sometimes semiglobular, as in *Geryonia*, (fig. 5,) sometimes the lower edge is everted, like a bell, as in *Oceania*, or contracted, as in *Pelagia*, (fig. 6.) The under or abdominal surface is almost invariably concave, arching upwards from its margin towards its central part; the concavity is greatest in *Ciroe*, and it is great in many of the *Oceaniæ*; in *Berenice* it is very slight; whilst, on the contrary, in *Tima*, and also in *Dianæa cerebriformis*, the under surface, instead of being concave, elongates itself into a ball. The body is deepest in the centre, and gradually thins towards the margin where the convexity and concavity unite. The margin is sometimes entire, as in *Eudora* and *Ephrya*, or lobed as in *Cyanea*, or fringed with tentacules few in number as in *Geryonia*, or very numerous as in *Æquorea*, (fig. 7.) The body of this order of Acalephs is a softish, jelly-like mass, loaded with water, transparent, generally colourless, or varied with brilliant hues; it is firmer about the mouth and roots of the arms, and about the margin, than elsewhere. When removed from the water, it soon dissolves almost entirely into a saltish fluid, so that of an animal which had weighed fifty ounces, or even twenty or thirty pounds, but a few grains remain. This fluid is, according to Rosenthal, contained in cells formed by delicate membranes, similar to the hyaloid of the eye, traversing it; and the whole is enveloped in a very delicate, external tegument, described by Gaede in *Aurelia aurita* and *Cyanea capillata*, studded with little round corpuscules, made up of still smaller ones. Rosenthal says that the skin of the convexity is thin, overspread with little heaps of points, and that the concavity is smoother but thicker, resembling the hyaloid membrane. Ehrenberg* describes two coverings to the convexity, a shining and generally smooth external one, which however has patches of little shotlike granules, and some scattered single flattened warty projections; it incloses a thick net of threads, which he thinks are vessels, from $\frac{1}{3000}$ to $\frac{1}{1000}$ of a line in diameter, forming hexangular meshes from $\frac{1}{100}$ to $\frac{1}{60}$, and sometimes to $\frac{1}{12}$ of a line, in width, containing here and there very minute granules of a whitish substance. The concavity, he says, is distinguished by having two net-like membranes in close connection with each other; the external of which has no patches of granules, but only scattered single ones; and the internal has scattered granules, but of similar character to the surrounding gelatinous mass. Concentric, circular and even radiating muscular fibres upon the under surface of these animals have been described by Basted, Spallanzani, Gaede and others; these Ehrenberg considers as very doubtful, but he thinks he has discovered muscular fibres in the pair of red lines which inclose each radiating process of the alimentary

* See his *System der Akalephen*.

* See his Paper *Ueber die Akalephen des rothen Meeres*.

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canal as it passes on the under surface from the stomach to the margin of the animal. The motions of these Acalephs are sometimes active, sometimes passive; if desirous to move forwards or upwards, they approximate the two halves of their margin together, so that the convexity is bent still more like a bent bow, after which the contraction suddenly ceases, and the animal is jerked onwards; having arrived near the surface, their umbrella remains outspread, and they are borne along by the mere motion of the waves, till they choose to descend, which is effected by contracting the whole disc and forming a ball, after which they sink. Upon their under surface are situated the apertures leading to the stomach, of which some have only a single one and others several, hence Brandt's division of the Order into *Monostomous* and *Polystomous* tribes; to these he adds a third, the *Astomous*, or Mouthless, to include the *Berenicides*, in which hitherto no mouth has been discovered. In the single-mouthed tribe, the aperture is in the centre of the concavity, either in its plane, as in *Æquorea*, *Aurelia*, and many others, or in a trunklike process, which depends like a pedicle, as in *Pelagia*, and others, and is either an elongation of the alimentary tube and mouth, or of the latter alone. In *Æquorea*, the circular mouth is surrounded with a simple rounded edge, which sometimes exhibits four or six folds, or very slight notchings; but in *Aurelia*, (fig. 8,) which has the mouth cruciform, the edge is lengthened at each angle into a clasper, which is of a somewhat trigonal form, rounded above, and hollowed slightly throughout the whole length of its under surface or base. When a trunk or pedicle exists, as in *Pelagia*, it is formed by the union for some extent of the edges of the claspers, near their origin from the concavity of the body, but an instance occurs, viz. *Melitea hyacinthina*, in which they are connected only at their extremity, and not at their origin. The form of the claspers is sometimes simple and roundish, sometimes leaf-shaped, and more rarely button-shaped, the stem being very short. Their length varies considerably, being either very short, as in *Æquorea* and *Oceania*, or longer than the diameter of the umbrella, as in some *Aureliæ* and in *Pelagia*; their edges are also occasionally fringed or armed with tentacules, especially towards the top. The many-mouthed or sucking Acalephs are of two kinds: 1. Those in which a simple cylinder or pedicle depends from the centre of the concavity of the body, communicating at its origin with the bottom of the alimentary cavity and pierced below by from four to eight small apertures, as in *Geryonia* and its congeners. 2. Those in which from four to eight processes or claspers dip down, either distinct or connected together, and open above separately into the alimentary cavity, whilst below the canal which each contains divides into several smaller ones, opening externally upon the edges and points of the claspers, and are the apertures by which the animal absorbs its food, as in *Rhizostoma*, (fig. 9.) The form and fringing of these claspers are similar to those in the monostomous tribe.

3. *The Siphonophorous Order*

Are remarkably distinguished by the absence of any stomach or alimentary cavity, and are divided by Eschscholtz into three families.

*a.* The *Diphydous Acalephs*, so named from their seeming resemblance to two animals connected together, which originates in their body being composed of two somewhat conical pieces, the apex of the posterior being received within the base of the anterior. These pieces Quoy and Gaimard* describe as having an independent life, and capable of living for some time after their separation. The anterior segment of the animal, considered by Eschscholtz to belong to the nutrient part, but not so held by Meyen, contains four cavities: 1. a large inferior one, the swimming cavity of the latter writer, occupying the whole length of this part, pointed in front, and expanding behind into a wide aperture, upon the edges of which are five teeth, and having attached to its interior, by a delicate thread, a sac of nearly corresponding form, exhibiting several longitudinal folds. Within the upper half of this segment are, 2. in front a spindle-shaped cavity, of which the use is not known, and behind it, 3 a conical cavity opening backwards, in which is received the apex of the second piece. Between this and the large inferior cavity is, 4. another, in which is attached the thread-like organ supporting those of reproduction and generation, and which either at once protrudes through its expanded posterior opening of this cavity, or is continued through the under part of the hinder piece. The posterior segment Eschscholtz thinks is the swimming organ: its shape is nearly similar to that of the anterior, but its forepart is lengthened into a sort of beak, which is received within the upper cavity of the former, as already mentioned; in its upper part is also contained a long cavity inclosing within it a plaited sac; whilst the lower part forms a pair of leaves between which the thread-like organ passes. This organ consists of a transparent cylindrical tube attached to the apex of the middle cavity of the anterior segment, and having slight indentations on its upper surface at regular distances, opposite which, on the under surface, little hollow branches are sent off, having at their tip a solid organ by which the food is absorbed, therefore called by Meyen the stomach; and from its under surface stretches out a very long thin tube studded with suckers, which seemed to be jointed. The little masses opposite the origins of the claspers are the ovaries. According to Meyen's notion, the large inferior cavity in the first segment, and the cavity in the second, are, by the alternate contraction and expansion of their walls, the locomotive organs of these animals, and the little sacs which they contain, respiratory organs. The sucking claspers, of which there are about twenty upon the tube, are rolled up when at rest, into as many little balls, but when outspread, form delicate threads three or four inches in length, as in *Diphya*, (fig. 10.)

*b.* The *Physaphorous Acalephs* are characterized by a bladder containing air, situated upon their upper extremity, by means of which they are floated like hydrometers: hence Cuvier has applied to them the name *Hydrostatic Acalephs*. The most simple form is that of *Rhizophysa*, (fig. 11,) in which the transparent egg-shaped air-vesicle has its middle surrounded by hollowed pieces of cartilage, and from its lower end floats loosely its long tubular body, from the sides of which project the simple claspers, which, as in the preceding family, serve the purpose of suckers. In *Stephanomia*, the very long alimentary tube is surrounded, except along its under surface, by rows of cartilaginous pieces, which overlap each other, between which protrude the sucking claspers, and organs considered by Quoy and Gaimard as ovaries. In *Physophora* (fig. 12.), the tubular alimentary

* See their *Observations Zoologiques* in the *Annales des Sciences Naturelles*, vol. x.

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canal is short; at its upper end is the air-vesicle, and below it two rows of hollow cartilaginous pieces, which are followed by a collar of delicate flask-like bags, containing fluid concealing the origin of the claspers, which surround the extremity of the body, and of which the form and length is very variable and elegant. The *Physaliæ* (fig. 13.) differ from the preceding, in having no cartilaginous organs; their air-vesicle is large and oblong, with thick semitransparent walls; its long axis is horizontal; at one end there is an aperture by which the air can escape, and upon its upper surface a beautiful crest extends nearly throughout its whole length, whilst beneath are sent down numerous tentacles and sucking organs, the former, of various size, having on one edge a narrow band, and on the other a row of kidney-shaped projections: they are ranged either singly or in masses, and are, at their origin, each furnished with a conical vesicle containing fluid; these vesicles Eschscholtz thinks correspond to those hereafter to be noticed in the *Holothuriæ*: other filaments, short and in bundles, are also found, which are believed to be reproductive organs.

c. The *Velellidous Acalephs* have within their soft substance a cartilaginous or calcareous plate or disc, which Eschscholtz calls a shell, either circular or consisting of two pieces, by the union of which an oblong body, either flat, or elevated to form a crest, is produced; in *Rataria*, this disc is oblong, much compressed and elevated, supporting upon its edge a leaf-shaped muscular membrane which forms a crest. In *Velella* (fig. 14.) the disc is cartilaginous, consisting of two pieces and oval; upon its upper surface is attached obliquely another cartilaginous plate enveloped in muscular substance. In *Porpita* (fig. 15.), the disc is round, calcareous, and marked above with concentric circles traversed by radiating stripes, but has not any crest. The sucking organs are in all the genera placed on the under surface, and the central one, which is largest, has been considered analogous to a stomach; and in *Velella* and *Porpita*, the margin of the soft covering of the disc is fringed with small tentacules or suckers which can only curve inwards. In *Rataria* and *Velella*, the elevated crest serves the purpose of a sail, and assists in the animal's movements; but *Porpita*, not having a crest, can only be moved by its tentacles. Probably, however, in all three genera the soft matter surrounding the disc, and which is said to be muscular, can bend it to a certain extent, and then suddenly ceasing to act allow the recoil of the disc by which the animal would be jerked forwards.

### Entozoons.

Rudolphi applied the name *Entozoa* to those animals which live within the internal parts of others, and divided them, from their form, &c. into the Cystic, Cestoid, Trematode, Acanthocephalous, and Næmatoid Orders. These, however, have been reduced by Cuvier to two, 1st. the Parenchymatous, including Rudolphi's first four, of which the body is filled with a cellulosity, or even a continuous parenchyma, and in which the greatest development of alimentary organs appears merely as ramifying canals with external apertures; 2nd. the Cavitary or Næmatoid, in which the external covering encloses a cavity, containing a distinct alimentary canal with mouth and vent. Instead of these designations, Owen prefers the names Sterelminthous for the former, and Cœlelminthus for the latter Order; and he adds a third,

The *Protelminthous Order*.

The most simple forms in this section are the *Zoosperms*, (*Mot. Org.* Pl. 1. fig. 1.) which exist at particular periods in the *liquor seminis* of all animals hitherto examined, and are therefore presumed to bear an important part in the reproductive process. Their shape is peculiar to each animal, but to a generally compressed oval body is attached a lengthy tail. No distinct organs have yet been discovered in them, but they move about with great activity. The *Trichina* (fig. 2.), which belongs to this Order, is more highly developed; it is like a cylindrical thread with one end rather larger than the other, and lies coiled up in a little elliptical cyst (a.) in the voluntary, but not in the involuntary muscles of the human subject. It has a smooth skin, inclosing a fine granular parenchyma, with a transverse linear double-lipped mouth at its larger end, from which commences a narrow intestinal tube; this soon becomes sacculated, but gradually loses that character, and takes a spiral or zigzag course as it passes towards the tail, to terminate in the vent.

The *Sterelminthous Order*,

As already stated, have no distinct cavity for their alimentary apparatus, which consists of simple pores in their tegumentary covering, or mere tubes continued from their mouths, without any other exit. They exhibit very considerable difference in form, varying from the globular shape of the *Acephalocyst*, to the lengthy, flat, tape-like *Tænia*. The *Acephalocyst* (fig. 3.) presents the most simple form; and from not exhibiting any contraction under the operation of irritants, Rudolphi denies their animal character, and considers them as mere morbid products. One species, the Pill-box Hydatid of Hunter, shows a simple, thin, semitransparent cyst, containing fluid, on the inner surface of which are little gemmules (a.); these, after a certain growth, drop into the cavity, assume an independent vitality, and produce other gemmules, which in like manner are developed and drop into their cavity, till a succession of cysts are produced, one within another, like a nest of pill-boxes. In *Cœnurus*, also a globular cyst found in the brain of sheep, numerous small vermiform processes, each with a proboscis and suctorial orifices, exist on its surface. In the more advanced *Cysticerci* (fig. 4.), one part of the cyst becomes lengthened into a neck and head; upon the tip of the latter is a papilla (a.) surrounded by a circle of small horny hooks (b.) which the animal is capable of inserting into the part to which it may choose to attach itself, and at the same time irritates so as to excite its secretion, which is absorbed by four mouths or suckers, encircling the head a little below the hooks. From the examination by Cloquet of another genus, *Echinorhynchus* (fig. 6.), in which however, instead of a papilla and suckers, there is only a single mouth, the proboscis is found to be a short elastic cylindrical tube, which can be retracted (a.), or projected (b.), by corresponding sets of muscles (c. d.); the numerous hooklets (e.) by which it is surrounded can also be depressed or erected, and therefore are presumed to be also provided with muscles. The transition from the globular to the tape-like, and seemingly jointed form of the *Tæniæ*, is first indicated in the *Cysticercus fasciolaris* (fig. 5.) of the rat, in which the body assumes a jointed appearance, and the vesicle becomes a mere caudal appendage. The Tape-worms are of considerable length,

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varying from three to ten feet, are flat, and are divided into segments, the hinder edge of one slightly overlapping that which follows. The two genera infesting the human body are remarkably distinguished from each other: the *Tænia solium* (fig. 7.), which exists in the English, Dutch, and Germans, has its fore part or neck narrow and merely marked by transverse rugæ, but the greater part of the body consists of oblong square segments: the head (a.) is small, wider than its length, has a papilla, booklets and four mouths. The *Bothriocephalus latus* (fig. 8.), which is peculiar to the Russians and Swiss, is nearly of the same thickness throughout, its segments are much wider than their length; and its head (b.), lengthy, without booklets or mouth. has on each side a longitudinal cleft (c. c.), or *bothria*. by means of which their food is sucked up. Some Entozoons, instead of attaching themselves by the head, have, as their fixing organ, a single transverse oval sucker, like a cupping-glass, on their abdominal surface, as the *Liver Fluke* of the sheep, *Distoma hepaticum* (fig. 9.), or there may be two of these, as in *Diplostoma*. Their mouth is placed at their anterior extremity. Some animals, which are not parasitic, but move about freely in the water, and are very voracious, are placed by Cuvier in close proximity to *Distoma*, from their general anatomical resemblance: these are the *Planariæ* (fig. 10.) and *Derostomata*, in both of which the mouth is situate near the middle of the ventral surface of the animal. In *Planaria*, the mouth is placed in a trumpet-shaped proboscis (a.), which can be projected or depressed from or into a cavity or sucker (b.), by which it is surrounded. He also places with them *Prostoma* and *Phœnicurus*, but these have the mouth in front. The motions performed by the individuals belonging to this order, excepting the *Planariæ* and its congeners, are not very extensive. All those which have a globular form are contained in cysts, and probably their only efforts consist in changing their position to different parts of their chamber. But even those which are attached to the surface of natural canals, as the *Tape-worm* in the intestine, and the *Fluke* in the ducts of the liver, are likely to be under similar circumstances; they are, however, capable of contracting their length very considerably, which is especially apparent in a recently voided tape-worm, the body of which at first appears to consist of mere narrow transverse segments, but these, after remaining in warm water a short time, gradually assume their oblong form. The ordinary movement of the *Planariæ* corresponds to that of a slug, but when it attacks its prey, it quickly throws itself around, and preventing its escape, attaches its sucker and speedily destroys it.

The *Cœlelminthous Order*

Have a distinct alimentary canal, with mouth and vent, and all have a vermiform shape. The *Guinea* or *Thread-worm*, *Filaria Medinensis* (fig. 11.), scarcely thicker than a stout thread, varies from two to twelve feet in length, and, to a corresponding extent, penetrating in the cellular tissue beneath the skin, if it dies, produces an immense series of little abscesses through its course, to effect its discharge. Sometimes the anterior portion of the body is very tapering, but gradually thickens, and has its hinder part of considerable comparative size, as in *Trichocephalus*; whilst, on the contrary, in *Oxyurus*, the hind part of the body is very slender and thread-like. The *Strongylus* (fig. 12.) has much the shape of the common Earth-worm, thick in the middle, and tapering towards the extremities; it is the largest species seen in the human body, and is found in the kidney, in one instance having attained the length of three feet. Both this and *Tricocephalus* are remarkable for the dilated pouch or sheath at the anal extremity (a.). The *Ascarides*, which are those of most common occurrence in the human subject, also belong to this Order: the *A. Lumbricoides*, or *Round Worm* (fig. 13.), is about fifteen inches in length; but of *A. Vermicularis*, the female is not half an inch in length, whilst the males rarely equal one-sixth. The mouth in the greater number of the Cœlelminthous Order is orbicular, simple, as in *Trichocephalus*, or surrounded by three papillæ, as in *Filaria* and *Ascaris*, or by six, as in *Strongylus*.

## Echinoderms.

The tubular feet with which the Starfish, Sea Urchins, and Holothuriæ are furnished, led Cuvier to place them together in his *Pedicellate* Order; but their form and internal structure vary so considerably, that they are justly entitled to be ranged in three distinct Orders.

The *Asteroid* or *Radiated Order*,

As the name implies, is star-shaped; the body or central part, containing the stomach, having rays stretching out from its margin, of greater or less length and number. Thus in one section of the genus *Asterias*, the body is pentagonal, and the slightly hollowing out of its edges hardly produces arms or rays, as in the *Gibbous Starfish*, whilst in the other section of the same genus, the body is deeply cleft, and the rays are of great length, as in the *Red Starfish*. In the *Ophiuræ*, the arms are of great length, and in *Euryale*, each arm, directly it stretches out beyond the body, divides into two branches, and these again into others, which again and again divide, assuming the appearance of interweaving branches of a tree, and which they employ for entangling their prey. The *Orange Starfish* is that of which the anatomy has been most admirably described by Tiedemann; it is not however found on our coasts, but the *Red* species, which is here very common, is amply sufficient to illustrate the peculiar characters of the Order. The arching upper surface is formed of "skin consisting of white, tendinous, glossy, tough, and thick fibres, twisted and interwoven in various directions, which represents the true corion," and is covered with pigment and cuticle. This net-work (*Mot. Org.* Pl. 1. fig. 14. A. a.) contains a large quantity of calcareous matter, so that when all the animal part has been removed by putrefaction, the arched form of the upper surface of the animal is still preserved, and therefore it may be more correctly described as a calcareous net-work supported in the net-work of the corion, which is best seen from within (B. a.). Upon its exterior are placed numerous little spiny or starlike, calcareous processes, of which the thin stems are attached upon little projections. The apertures left between this net-work give passage to delicate tubes (B. b.), through which the water is received into the general cavity of the animal for the purpose of respiration. At the junction of the arms with the body, between each two arms, the upper convex tegument sends down a sickle-shaped process (A. c.) toward the aperture of the mouth, so that their number corresponds to the number of arms, and one of them is grooved to give lodgment to two peculiar canals, one for the heart and the other containing sand (d. e.). The situation of these is indicated by a large flat calcareous button upon the



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upper surface of the body (A. f.). Upon the under surface of the animal, and in the centre, is a deep depression, into which the mouth opens, surrounded by five tooth-like processes, one placed at the angle formed by the junction of each two arms (B. b. h.); they are moveable, and probably assist in taking the food. From this central part stretch out the arms, at first broad, but gradually tapering to a point. Their under surface or base consists of a series of pieces or vertebers (A. g. g.), gradually diminishing in size from the base to the tip, of which the solid central part, or body, is wider than its thickness, and from each side sends out a transverse process, first thin and then expanding, upon the front and hind edge of each of which a little projection is seen joining with similar ones on the neighbouring pieces, and thus a succession of apertures (h. h.) are left on each side of the central column. The extreme point of each transverse process has affixed to it a little oblong calcareous piece, to which is attached a larger piece, having its under surface studded with little rounded processes for the articulation of the hollowed bases of little spines. The junction of the vertebral bodies forms a central pillar (l.), extending from end to end of each arm and the roof of a deep groove which stretches from the mouth along the under surface (B. e.), and has on each side a longitudinal row of conical tubular soft processes or feet (A. B. i. d. c. a. a.) which can be protruded or retracted through the apertures (A. h.) between the transverse processes; and these are bounded externally by a row of pointed movable spines (B. e. e.), directed obliquely forward and outwards, by means of which the animal walks. Besides these, numerous flattened rounded processes are placed on the edges of the foot grooves, which when the feet are retracted face towards each other, and cover up both them and the grooves, but when the feet project are directed downwards. The protrusion of the feet is effected by a system of organs which Tiedemann calls "the vascular system of the rays and feet," and consists of vessels and vesicles. The mouth is surrounded by a circular vessel, which, in the *Orange* species, has, opposite each of the angles formed by the junction of the arms with the central body, a pair of small roundish, brown, and seemingly glandular bodies; between each pair a vertical branch rises from the circular vessel and receives into it the lengthened necks of three or four little pear-shaped vesicles. In the *Red* species the glandules do not exist, but a pair of globular delicate vesicles (A. k. k. C. h.) are situated at the commencement of each arm, and from these pass a pair of slender tubules to the circular vessel. Opposite the groove in each arm, the circular vessel sends out a long horizontal branch, which stretches out to the very extremity of the arm, and gives off in its course lateral branches, terminating, in the *Orange* species, in two rows of little oval vesicles, but in the *Red*, in four rows of conical vesicles (C. e.), which are connected with the bases of the tubular feet. The little round bodies on the circular vessel, Tiedemann thinks, separate the colourless fluid contained in this apparatus from the blood; and the protrusion of the feet is effected by the contraction of the pear-shaped vesicles impelling it through the vessels into the soft feet, which, on the contrary, in their retraction, drive the fluid back again into the vesicles.

2. *The Echinoid Order.*

This division is generally known by the name of *Sea-Urchins*, or *Sea-Eggs*, their exterior consisting of a calcareous shell, which in some, as the *Echini*, has a flattened spheroidal shape, its mouth, armed with five strong teeth, being below, and the vent above. In others, as *Galerites*, it has a conical form with swelling sides, the mouth is central in the base, and the vent at its edge; and in some, as the *Spatangi*, its inferior surface, of an oval shape, flat or slightly hollowed, has towards its front margin a transverse toothless mouth, and the vent near its hind edge, whilst its upper surface is more or less convex. The shell consists of an immense number of polygonal calcareous pieces, connected together by cellular tissue, and arranged in ten bands, which descend from a circlet of pieces at the top of the shell, belonging to the oviducts, towards the under part or base. Five of the bands consist of larger pieces (fig. 15. A. a. a. B. a.) than the others, and alternate with them; but each band, whether small or large, consists of a double row of these calcareous pieces. The pieces of the smaller bands (A. h. B. b.) are characterized by being perforated with numerous apertures, through which similar hollow feet to those of the Starfish protrude, and these bands have therefore been called *ambulacres*. The larger bands (A. a. a. B. a.), or *interambulacres*, have no such apertures, but are provided with little rounded studs, upon which move the hollow bases of numerous large calcareous spines (C.). Upon both bands smaller spines are seen, and all seem to be moved by a contractile power in the delicate membrane which invests the whole shell and the bases of the spines. In the *Echinus* and its congeners the calcareous bands break off suddenly below, and leave a large space filled up by the oral membrane, in the centre of which is the aperture of the mouth, and around it ten little protruding respiratory tubes, by which the sea-water is received into the cavity of the shell. A similar abruption of the bands occurs at the upper end (D.), in the centre of which terminates the vent (a.), surrounded by a ring of five pieces (b. b. b. b. b.), each perforated by a hole (c.) in which the oviducts terminate.

In *Echinus lividus* Tiedemann has described the apparatus moving the feet, which corresponds very nearly to that of the Starfish. Within the shell five vessels pass up along the middle of the five ambulacres, giving off numerous lateral branches to the soft feet, and become smaller and smaller till they cease above; but at their lower ends they pass through five calcareous arches which run round the inner edge of the large lower aperture of the shell, filled up with membrane, and leaving only the small circular opening of the mouth. Having passed through these arches and reached the upper surface of the membrane just mentioned, they expand into five pear-shaped vesicles, the action and use of which are similar to those in the Starfish. A very curious apparatus, called Aristotle's lantern, and to be considered as the jaws of the *Echini*, is situated above the membrane within the shell; it consists of five triangular pyramids, with their bases above, and their sides so apposed, that together they form a pentagonal pyramid, through the centre of which rises the mouth to join the gullet at its base. The inner edge of each pyramid towards the mouth is deeply channelled from its base to its tip, giving lodgment to a long triangular tooth, which protrudes through the tip, and appears in the opening of the oral membrane. The corresponding edges of the bases of the pyramids are connected by five little compressed, ob-

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Zoology. long, quadrangular pieces, which stand out like radii around the gullet, and by their inner extremities give attachment to as many semicircular pieces, which curve over them, gradually expand, and terminate, by dividing into two branches like the letter Y. The motions of this apparatus are very great and complicated, as may be presumed from Cuvier describing no less than thirty-five muscles connected with them. In the other members of this order, as for instance the *Spatangi*, neither teeth nor jaw exist, but the lower edge of the transverse mouth projects somewhat like a shovel, and thus readily conveys into its alimentary canal the sand from which it abstracts its nourishment.

3. *The Holothuroia Order*

Differs from either of the other Echinodermous orders in the skin being entirely devoid of any earthy contents, but it is very thick and strong, consisting of a whitish fibrous tissue, which interweaves in various directions, leaving apertures for the passage of the dorsal tubes (fig. 16. A. a.) which penetrate through several wart-like projections on the back, and for the protrusion of the feet (b. b. b.) upon the belly, which are in great numbers. The animal is of a tubular form, and upon its fore extremity is a crown of twenty tentacules disposed in two rows, and having the extensile mouth (c.) in the centre, each tentacule being cylindrical, and having its expanded end fringed. A longitudinal section of the external skin exhibits the apparatus by which both tentacules and feet are moved, and which has a close resemblance to that of the other orders, but rather more simple. A circular vessel (B. & C. a.) surrounds the stomach, from which project five branches (b. b. b. b. b.); three on the under and two on the upper surface of the animal, having at their origin little brownish bodies upon the circular vessel. The branches stretch forwards and empty themselves into another circular vessel which is contained within a calcareous ring (D.) consisting of ten pieces, of which the larger are oblong and have two toothlike points in front, whilst the smaller, which are short and narrow, have but one. With this vascular second ring all the tentacules above the mouth are in immediate connection by as many apertures, and in addition to these, five vessels (B. & C. c. c. c. c. c.) are given off from the ring, which run back throughout the whole length of the body, gradually diminishing in size as they give off lateral branches to terminate in the oval vessels situated between the skin and muscular covering, which are connected with the feet, and also with the dorsal tubes. With the posterior circular vessel are connected two oblong oval vesicles (B. & C. d. d.), which when the feet are retracted contain fluid, but are contractile and capable of ejecting their contents, and thus protruding both feet and tentacules.

The following classes make up the great division to which Cuvier has assigned the name ARTICULATE ANIMALS, from their external covering, however different in substance, being jointed like armour.

ANNELIDS, or REDBLOODED WORMS.

The general covering of these animals, which are mostly cylindrical, as the *Nereis*, *Eunice*, and *Earth-Worm*, but sometimes of an ovaloid shape as the *Sea-Mouse*, consists of a series of rings or segments of soft tegument, varying in different genera from twenty to more than five hundred, and connected by thinner bands. The first segment, either singly or in connection with others, often forming a larger ring than the rest, is easily mistaken for the head, and the last is furnished with a plaited vent turned upwards, or forms a tube of greater or less length, with the vent at the tip, facing backwards or downwards. Each ring is generally furnished with a pair of feet to which are attached *cirrhi*, *elytra*, and *branchiæ*, as in the *Sea-Mouse* (fig. 17.); but others, as the *Earth-Worms* (fig. 19.), have only a few delicate bristles, and some, as the *Leeches* (fig. 20.) are devoid even of these. Each foot is usually divided into two oars or blades, an upper or dorsal (*), and a lower or ventral one (**.), which are either wide apart as in the *Sea-Mouse* (fig. 17. A.), or closely approximated as in *Glycera* (fig. 21); but sometimes the foot has only a single blade, as in *Eunice* (fig. 22.). Each blade consists of a sort of fleshy nipple (a.) upon which are implanted subulate or awl-shaped bristles, *setæ subulatæ*, which are of two kinds. Those grouped in bundles or rows are called *festucæ* (b.), of which the ventral blade has usually but one rank or bundle, whilst on the dorsal there are two or more. These festucæ perforate the skin, and with their sheaths stretch into the interior of the body, where they are connected with the muscles by which they are moved. They are numerous and slender, cylindrical, prismatic, flattened, straight or slightly curved, and almost invariably tapering from the base to the tip; towards which some have a little tooth, and have a forked appearance, whilst others are slightly dilated and garnished with asperities. Some have the tip bent, curved, or twisted, and surmounted with a ridge or small movable blade. The greater number, however, are straight and merely pointed, solid, tough and stiff; in a few instances, however, they are tubular, and sometimes are delicate and flexible like hairs. Other bristles, distinguished by their black or brown colour, and of which there are never more than two, and rarely more than one in each blade, are called *aciculi* (c.). These are much larger than the former, are straight, conical, very pointed, and contained in a sheath, through which they may be seen, and of which the orifice is known by its prominence. Another kind of bristles are found only in the Tubicular Annelids, and never in both blades of the same foot. They are enclosed in the thickness of the skin, protrude but very slightly, and are disposed in one or two rows on a transverse leaf or nipple; but sometimes there is only a single one, thin and long. If of the former kind, they are shaped like little laminæ armed with hooked teeth near their tip; if of the latter, as in *Chloræma Edwardsii* (fig. 23. d.), they terminate in a single hook; but in either case, they are called *uncinuli*. In many, the subulate bristles are entirely deficient on the hind part of the body, and so also the hooked ones on the fore part, but the latter are replaced by spatulate bristles, *spatellulæ*, which have their tip flattened horizontally, and rounded like a spatula, as in the *Palmyra* (fig. 24. d.). Each of the tegumentary segments is generally furnished with two pairs of *cirrhi*, an upper or dorsal (e.), and a lower or ventral one (f.), which spring from the base of their corresponding blades, and sometimes from the very top of the dorsal. The *cirrhi* are tubular, subarticulate, usually retractile threads, of which the upper one is generally of greatest length. Sometimes the cirrhi of the anterior segments are considerably larger than those immediately subsequent; such (fig. 17 e. f. g.) are then called *tentacular*,



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and the setiferous nipples of the same segments become rudimentary, or are entirely deficient. Sometimes the ventral cirrhus is deficient, as in *Glycera* (fig. 21.); sometimes the dorsal, as in *Aphrodita* (fig. 17. A.), which generally happens where the leg is furnished with an elytron, but in some instances, as in *Sigalion* (fig. 25. e.), the dorsal cirrhus is present as well as the elytron. In other instances, as in the *Sand-Worm* (fig. 18. A.), both cirrhi are deficient. The *elytra* (h.) are membranous scales attached to the bases of those feet which have not a dorsal cirrhus, and usually alternate with them, as in *Aphrodita*; in one species of which, *A. Hystrix* (fig. 17.), they are superficial, and in another, *A. Aculeata*, they are concealed by a loose skin overspreading the back. Their edges are either regular, as in *Aphrodita*, or fringed as in *Sigalion* (fig. 25. h.). The *branchiæ* or gills vary in form and position, but will be subsequently described with the Respiratory Organs. The locomotive organs of *Earth-Worms* are simply sharp-curved *bristles* (fig. 19. A. a.), each implanted on a little nipple (b.), from and into which they can be projected or retracted. On the first four or five segments there are not any bristles; but several of those following have two pairs (B. a. a.), which being on the under surface are called *ventral*; subsequent rings, generally behind the *clitellum* (A. d.), though without regularity, have other two pairs (B. e. e.), which are called *lateral* from their situation on the outer side of the ventral. In the *Leeches* (fig. 20.) and their congeners, even these bristles are deficient, and locomotion is performed in the water by flattening and undulating the body; and on land by projecting the fore part of the body, fixing the oral sucker (A. a.) and then drawing forwards the hind part, the sucker or foot (B. b.) on which having attached itself, the anterior extremity is again projected.

Some of this class are furnished with distinct heads and trunks, but others are headless. The head is merely a little inarticulate projection on the upper surface of the body in front of the first segment, and supports three distinctly articulate and retractile antennæ, as in the *Sea-Mouse* (fig. 17. D. j. k. l.), or more, as in *Lycoris*, and *Leodice*, of which the single one is always nearer than the others to the segment. Upon it are also found, behind the antennæ, two eyes, as in the *Sea-Mouse*; or four, as in *Polynoe squamata*. The fleshy trunk which forms the mouth, and consists of one or two rings, is capable of projection or retraction, and Milne Edwards says is formed by the anterior part of the alimentary canal, which can be inverted and protruded like the finger of a glove; sometimes it is devoid of tentacules, as in *Palmyra*, but in others they exist scattered upon the trunk, as in *Myriana*, or encircling the mouth, either singly, as in *Polynoe*, or in tufts, as in the *Sea-Mouse*. The trunk is also commonly furnished at its orifice with jaws, which are generally placed laterally and move horizontally; they are either cartilaginous, horny, or calcareous, and consist either of a single pair, as in *Lycoris*, or of two pairs, as in the *Sea-Mouse*, or there may be three or four pairs with an unpaired one upon one or other side, as in *Leodice* and *Œnone*. In some kinds, as *Hesione*, the trunk is unprovided with jaws.

The *Serpuloid*, *Lumbricoid*, and *Hirudinoid* orders have no head, and consequently neither antennæ nor eyes, except in the latter, nor is the mouth furnished with jaws in the two former orders, but only with extensile lips, which are either unprovided with tentacules, as in *Clymene* and in the *Earth-Worms* (fig. 19.), or the tentacules are very short papillæ placed on a circular lip, as in *Arenicola*, but more commonly of great length, and supported on a little fullness above the lips, as in *Serpula* and *Terebella*. The order of *Leeches* are distinguished by the sucking discs with which both their extremities are furnished. The oral sucking disc, *capula*, consists of the first and some of the subsequent segments of the body, either separate, as in the *Leech* (fig. 20 A. a.), or collected into one seeming piece, as in *Branchellion*: it varies in depth, and in its bottom is the mouth, armed with three jaws or teeth (B. a. a. a.), placed in a triangular form, the apex in front; these are either simple projecting points, as in *Branchellion*, or have their cutting edge armed with two rows of very delicate and close set denticles, as in the *Common Leech* (C. b. b.). The anal disc, *cotyla* (D.), is simply an expansion of the last segment of the body, as is proved by the position of the vent (D. a.), which is placed not in its centre but in front and above it. The eyes, for which this order is remarkable among the Annelids, are either two, four, six, eight, or ten, disposed either in one or two transverse lines, or in form of a trapezium upon a single segment, when the oral disc is inarticulate, or upon many, when it is articulate in a semicircular form, as in the *Leech* (E.)*.

### Myriapods.

These animals are immediately distinguished from the Annelids by the presence of jointed legs, of which the number is so great that they are commonly known as Centipedes or Millipedes. The rings which envelope their body are horny and more or less hard; are imbricated or slightly overlapping each other, and are either entire and cylindrical, as in *Iulus* (*Mol. Org.* Pl. 1, fig. 26. A.), or consisting of two semicircular pieces united by membrane, and depressed, as in *Scolopendra* (fig. 27. A.). The number of rings varies, increasing with the age of the animal, but in the *Scolopendræ* it ranges between fifteen and twenty-one. Neither ring is furnished with more than a single pair of *stigmata* or orifices of air-vessels, and sometimes only the alternate rings are so furnished, as in *Scolopendra*. The row of pores on either side of the body are for the secretion and discharge of an acrid and fetid fluid, which serves as a sort of defence. The rings exhibit scarcely any difference between each other excepting the head or skull, which upon its upper surface presents only a shield-like disc (fig. 27. A. a.), supports the eyes (b. b.) and the antennæ (c. c.), and overhanging the parts composing the mouth, which consists, according to Savigny, of a broad upper lip (*chaperon*, Sav.) (B.), of a pair of mandibles (C. C.), a lower lip (D.) formed by the junction of a pair of primary (a. a.), and another of secondary maxillæ (b. b.); hence the term *Chilognathous*, or lip-jawed order, applied by Latreille to the *Iuli* and their congeners. Immediately beneath the mouth in this order are attached the anterior three pairs of legs: the first pair (E.) have their first joints or hips, *coxæ*, soldered together, the second or thighs, each consisting of a single joint, and supporting the third, or *tarsus*, which is not

* Audouin and Milne Edwards have given a series of excellent papers on the Annelids, entitled *Classification des Annélides, et Description de celles qui habitent les côtes de la France*, in the *Annales des Sciences Naturelles*, vols. xxvii. xxviii. and xxx. from which the preceding description has been mostly derived.

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distinctly clawed: the hips of the second pair (F.) are also connected, but their thighs have two joints, and their tarsi are clawed; the third pair (G.) resemble the other legs presently to be spoken of. In the *Scolopendræ*, besides the jaws and lips just mentioned (fig. 27. B. C. C. D.), there are two auxiliary lower lips, the first (E.) consisting of two long spiny and clawed palpi (a. a.), and the second (F.) covering the whole mouth, and surmounted with two stout palpi (a. a.), each armed with a curved, hard, and much-pointed claw. These auxiliary lips Savigny considers to be actually the first two of the three pairs of legs referred to in the *Iuli*, as in them can be distinguished the corresponding *coxæ*, *femora*, *tibiæ* and *tarsi*, the latter with their claw: hence arises Latreille's name *Chilopodous*, or lip-footed order, applied to the *Scolopendra* and its allied genera. The last or claw-joint of the second pair of these lip-feet is strongly hooked, movable, and perforated for the discharge of a poisonous secretion. Both orders have the head furnished with a pair of jointed organs called *antennæ*, which in the Chilognathous have seven joints (fig. 26. A. b. b.), usually thickening towards their tips; but in the Chilopodous there are fourteen, or even more, joints (fig. 27. A. b. b.), which become very slender at their extremities. All the rings of the body, except the first, and sometimes the last two or three, support pairs of legs (figs. 26, 27. A. c. c.), but it is disputed how many pairs. Savigny says the *Iuli* have but one pair of legs to each ring; only the rings generally are alternately scaly and membranous, and the latter are hidden under the former. Latreille, however, states that in the Chilognathous order, from the fourth, fifth, or sixth ring, each supports two pairs of legs, but in the Chilopodous rarely more than a single pair, and those, attached to the last ring, stretch backwards like a tail (figs. 26, 27. A. d. d.). The number of joints to each leg are seven, of which the first or *coxa* is very short and thick, and the last only a sharp hook: the others are nearly of equal length in the *Iuli*, but in the *Scolopendræ* the four following the *coxa* are more slender, and the sixth very small.

### Arachnidans.

The trunk or body of this class, differing as to the solidity of its external covering in its several orders, consists either of two distinct though connected regions, or is but one undivided whole. In the former case, the anterior region includes the head and thorax undistinguished from each other by definite boundary, and therefore called the cephalo-thorax, whilst the posterior region is the abdomen. These regions are either well-marked by their connection being simply a narrow pedicle, as in the *Spiders* or *Araneid* Order (fig. 28.*); or their division is less discernible, no diminution of size occurring at the junction of the two regions, the anterior margin of the abdomen being received within the posterior margin of the cephalo-thorax and slightly overlapped by it, as in the *Scorpions* or *Scorpionid* Order (fig. 29 *). These two Orders form Dugès's *Tomogastric* section of the Arachnidans, he considering the tail of the Scorpions to be their abdomen. Those which have the trunk undivided into parts, and therefore called thoraco-gaster, he places in his other, or *Hologastric* section, consisting only of the *Acaridan* Order, or *Mites* and *Ticks* (fig. 30.).

The *Cephalo-thorax* (fig. 28. A†) is so named from the consolidation of the head with the chest, the boundary between the two, on the upper surface, being indicated in the *Spiders* by a V-shaped impression, within the branches of which is the head (a.), supporting the eyes and all the pieces belonging to the mouth, and behind it the chest (b. b.), giving attachment to the legs. The ringed construction of the Cephalo-thorax is not yet fully made out, at least so far as regards the head; but Audouin describes the chest of the *Birdspider* as provided beneath with a shield composed of four consecutive pieces, which are interposed between the corresponding pairs of legs; whilst above there is a convex plate with the V-shaped cleft in front, and marked more or less distinctly with transverse lines indicative of the original existence of separate pieces (fig. 31.). The mouth is surrounded with several pieces which are commonly known as lips, mandibles, and maxillaries, and are either distinct or conjoined, to form a more or less perfect sucking apparatus. The space between the eyes and mandibles which occupies the front of the head is called the upper lip, *labrum*; it is very short in the *Cross Spider, Epeira diadema* (fig. 28. A. c.), in the *House Spider*, and others; but in *Pholcus* (fig. 33. e.) it is large and lengthy. Immediately beneath this lip are placed the mandibles (fig. 28. C. a.), the *forciples* of Savigny, *chelicères*, or *antennе-pinces* of Latreille, who objects to the term "mandibles" usually applied to them. They are a pair, and each consists of two joints, the terminal one (1.) being single-clawed. The principal joint or stem (2.) is cylindrical or conical, with a deep groove, into which the claw folds or bends itself up, its motions being vertical and not horizontal, like those of the mandible of Insects. The forciples in some species (fig. 32.) are also remarkable for a perforation (a.) in the terminal joint, connected with a fine canal (b.), which runs back to a poison vesicle (c.) lodged in the thorax, and by the injection of which the spider almost immediately destroys its prey so soon as it has seized it. Savigny considers that the forciples do not bruise the food, but only hold it fast and apply it closely to the jaws, by which its juices are expressed into the pharynx. Behind and beneath the forciples are the *maxillaries* or *jaws* (fig. 28. C. b. b.), so called, which are really but the development of the radical joints of a pair of legs: the inner edge of each is ciliated, and from the outer springs the remaining five portions of the leg, generally said to form the *maxillary palpi* (c. c.), diminishing in size and having the terminal piece in the *True Spiders* merely a simple claw, at least in the females; for in the males of some kinds the penultimate joint exhibits a peculiar concave body, from which a membranous vesicular glandiform substance protrudes, terminating in some curved and projecting hooks of greater or less length (c.*). This was formerly considered to be the penis, but Treviranus has disproved the assertion. The last piece is the *sternal lip* (d.), situated between the jaws and resting upon the front of the sternum or underpart of the chest. Lyonnet also speaks of a delicate tongue contained within the mouth, by which the *Spiders* are enabled to suck up the juices of their prey.

The under surface of the Cephalo-thorax in *Spiders* is covered with a heart-shaped coriaceous plate (fig. 28. B. a.), with its apex behind and its lateral edges festooned by the insertions of the legs, of which there are four pairs (b. c. d. e.) specially for locomotion, and each consisting of a hip, *coxa*, followed by one or two supplementary joints, a thigh consisting of two pieces, a leg of two also, and a tarsus or foot divided into several joints, of

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Zoology. which the terminal is armed with one, two, or three claws on a common stem, or with a vesicular clawless pedicle.

In the *Scorpions* there is not any distinction of head and chest, but the front of the Cephalo-thorax is divided into two lobes (fig. 30. A. a. a.), each furnished with three smooth eyes (b. b.) by a cleft which runs into a groove (c.), continued longitudinally on its upper surface, and passing between a pair of smooth eyes (d. d.), situated above its middle. These lobes might be called a cleft *upper lip*, for immediately beneath them project the *mandibles* (e. e.), which are short and straight, and consisting each of a double claw. The maxillaries (f. f.) are small, but remarkable for the enormous size of their palpi (g. g.), which resemble the claws or first pair of walking legs of *Lobsters*, the last joint of each consisting of a pair of large claws, of which one only is movable; and hence the Family to which they belong is called *Pedipalp*. In the genus *Phrynus*, which belongs to this Family, the large maxillary palps terminate in single claws (fig. 34.).

The *Abdomen* is of very simple character: it may be either soft and its rings blended together, as in the *Spiders* (fig. 28. A. B.††), or its rings may be horny and distinct, as in the *Scorpions* (fig. 29. A. B.††), of which the first six are broad and flat, but the hinder six much narrower and forming the tail, of which the last but one ring is much longer than the rest, and the last (D. 11. 12.) has a curved and very sharp point, under the tip of which, two apertures (12. a. a.) allow the discharge of their poisonous secretion. Upon the under surface of the abdomen are also observed the apertures of the air-apparatus: these *stigmata*, as they are called, are very distinct in the *Scorpions*, as narrow fissures, four on each side (fig. 29. B. o. o. o. o.), and lead to pulmonary bags, in which are seen numerous folds like the leaves of a book, considered by Treviranus and Meckel to be bronchial laminæ, but held by Müller to be true lungs, because they can be distended with air. The Arachnidans in which such respiratory sacs are found are called *Pulmonary*, and include the *True Spiders*, *Tarantulas*, and *Scorpions*.

In the *True Spiders*, or *Spinners* as they are called, near the vent are some little teat-like processes called *spinnarets*, of which there are generally described only two pairs, but Blackwall* says that all the spiders which have come under his observation have two, three, or four pairs of spinning mammulæ, conical or cylindrical in figure, and composed of one or more joints each. The pair nearest the vent he calls superior spinners (fig. 28. D. a. a); those most distant from it, inferior spinners (b. b.); and those between them, the intermediate spinners (c. c.). Their surface is covered with numerous papillæ, of which the greatest number in the British Spiders are found in the larger *Epeiræ*; and Blackwall thinks it probable that the total number in adult females of this genus does not much exceed a thousand; but in others it varies from four to one hundred. The number varies in the different spinnarets: in *Epeira* and others they are more minute and numerous on the inferior pair, and in *Segastria senoculata* the intermediate spinnarets have each only three large papillæ. On the contrary, in *Drassus*, the intermediate spinnarets have most papillæ, and the inferior few and large ones. Through these papillæ is poured out the fluid secreted by a proper organ within the abdomen, and which fluid almost immediately after its effusion concretes to form a filament, which, joining with those from the other spinnarets, produces the common thread of which the spider weaves its web. The minute apertures between the papillæ, giving to the spinnaret the sieve-like appearance described by Lyonnet, Treviranus, and others, and by them supposed also to give out filaments, Blackwall denies as performing that office; nor does he admit the anal palps, so called by Lyonnet, Savigny, &c., but says they are only the superior spinnarets (which, as well as the inferior of many *Spiders*, are triarticulate), of which the terminal joint is greatly elongated, thickly clothed with hairs, tapering to a point, and having the papillæ, in form of hair-like tubes, dilated at the base, distributed commonly along its inferior surface, as in *Tegenaria domestica*, &c.

The *Gastro-thorax*, as already mentioned, is the characteristic form of body in the *Acaridan* Order, in which neither head, thorax, nor abdomen are distinguishable from each other, as in *Trombidium Phalangii* (fig. 30.). In two, however, of the seven Families into which Dugès divides this Order, viz., the *Bdellian* and *Oribatian*, there is a distinct separation of the thorax and abdomen, as in *Scirus Elephas* (fig. 35.). But in neither Family is any distinct head observable; for the lengthening of the front of the body into a proboscis occurring in some genera is not to be mistaken for a head. Eyes have not been discovered in the *Gamasian*, *Ixodian* (Ticks), or *Acarian* (Mites) Families; but in the others they exist variously placed. In the *Trombidian* Family they are generally situated at the forepart of the body near its edges; in the *Hydrachnian* on the fore and upper part; in the *Bdellian* on each edge of the thorax, either two, as in *Bdella*, or one, as in *Scirus* (fig. 35. a. a.), with a long bristle (b.) stretching out behind each. The under surface of the body is protected anteriorly by an imperfect sort of shield, formed by the expansion of the *coxæ* or first joints of the legs, as in *Hydracne globulosa* (fig. 36. A. a. a.); and in the same animal an attempt at forming a dorsal shield appears in the microscopic granules collected in two patches on its upper surface (B. a. a.); and in *Uropoda* such a defence really exists. All the Order are furnished with four pairs of legs, generally consisting of seven joints, which vary in shape according to their uses, and are correspondently named. The *stigmata*, or apertures for the admission of air, are on the under surface, and only two, which, instead of leading into sacs as in the former orders, are the commencements of air-vessels which penetrate every part of the body very minutely, hence this kind of respiratory apparatus is called *Tracheal*. The organs of manducation are distinguished from those of the *Spiders* and *Scorpions* in not being free, but supported by a spoon-like or sheath-like lip, and the maxillary palps alone are disengaged. In *Raphignathus* (fig. 37.) the conical lip, *labium* (a.), projects in front of the body, and has resting on it a pair of two-jointed jaws (b. b.), the basal joint (b.) being fleshy and of an ovaloid figure, and the terminal joint (b.*) consisting of a conical piece like an awl, with a bristle standing out from its base: its palp (b.**) is very large. In *Smaridia* (fig 38.) the lip (a. a.) curls up on each side, forming a semi-canal, in which plays a jointed trunk (c. c.), produced by a lengthening of the front of the body, and capable of retraction, like the

* See his paper on *The Difference in the Number of Eyes with which Spiders are provided*, &c. in *Linn. Trans.* vol. xviii. p. 601.

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joints of an opera-glass: in this trunk are a pair of sword-shaped jaws (b. b.) which are capable of projection from it: the palps (b.**) are placed at the anterior end of the lip. In one of the Dog Ticks, *Ixodes Plumbius* (fig. 39.), the palps (b.**) form a sort of roof over and hide the mandibles; but when these are removed, and the mandibles separated, they (b. b.) are seen toothed on the outer edge of their terminal joints, and between them the lip (a.), covered with little teeth, directed backwards. In the Cheese Mite, *Acarus Domesticus* (fig. 40.), the lip (a.) is lengthy, and has its edges thickened by the union of the palps (b.**) with it.

### Crustaceans.

The distribution of these animals into the two subclasses, Entomostracous and Malacostracous Crustaceans, first proposed by Latreille in 1802, had been pretty generally adopted by zoologists till the appearance of an extract from Milne Edwards's paper, *Recherches pour servir à l'Histoire Naturelle des Crustacés Amphipodes*, read before the Royal Academy of Sciences of Paris, in March, 1830, in which the construction of the oral organs is made the foundation of their division into two sections: the *first* including those of which the mouth is not furnished with any special organs of mastication; and the *second* composed of such as have proper masticating organs, viz., a pair of mandibles and one or more pairs of maxillaries or jaws. Subsequently, however, in his excellent work, *Histoire Naturelle des Crustacés*, 1834, Edwards found it necessary to form a third section for the Xyphosorian Crustaceans, which he had previously included in his first section, to which they had little resemblance, and indeed are more nearly allied to the second, although sufficiently distinct from it also to justify their formation into a distinct section. He therefore arranges the Crustaceans in the three subclasses: 1. Suckers (Mot. Org. Pl. 2, fig. 1.); 2. Xyphosures (fig. 2.); 3. Masticators (fig. 3.); and these, with the exception of the second, he divides into several orders, the sub-class, Suckers, including the *Araneæform*, *Lernæform*, and *Syphonostomous* Orders, and the subclass, Masticators, comprising the *Entomostracous*, *Branchiopodous*, *Trilobites* (fossil), and *Edriopthalmous* legions, with their several orders, all of which are devoid of true branchiæ or gills, together with the *Podopthalmous* legion, and its orders, which have perfect branchiæ, and are the most highly developed of the whole class.

The tegumentary covering of the Crustaceans varies considerably in hardness, being almost brittle as earthenware in the *Lobsters*, *Crabs*, and their allied genera; horny, as in the *Prawn*, &c. and scarcely more than a thin membrane in *Branchipus*. With the exception of the *Ostracoid* Order of the *Entomostracans*, the disposition of the tegument in all the Crustaceans is towards the formation of rings or segments, the general number of which is twenty-one, and in a few instances even more; but in some there are fewer, in which case the deficient rings are the hindmost. These twenty-one rings are not all distinguishable in any one individual; more or less of the anterior rings are generally consolidated into a single piece, and the number of rings thus united is shown by the number of the pairs of legs attached to it, each pair of legs being supported by a single ring. Milne Edwards describes each ring or segment as consisting of two portions, each composed of four pieces; in the upper or dorsal portion (fig. 7. A.), the middle two pieces (a. a.) form the *tergum*, and the lateral (b. b.) the flanks, *epimera*; in the lower or ventral portion (B.), the middle two (c. c.) construct the *sternum*, and the lateral pieces (d. d.) are the *episterna*: between the epimera and episterna are the spaces for the articulation of the legs. The body of these animals is divided into three sections, the head, chest, and belly, *caput*, *thorax*, *abdomen*, each consisting of seven rings.

In the *Head*, it is generally impossible to distinguish the rings of which it consists; and in many instances, as in the *Lobsters* and *Crabs*, it seems as if the head and chest were consolidated into the large shell or carapace, in which the so-called thorax is enveloped. The presence of the first cephalic ring (fig. 9. t.) is only indicated in these highest Crustaceans by its connection with the little pedicles (a.*) supporting their eyes (a.**); from whence they are called *Podopthalmian*, and include the two most highly developed Orders, viz., the *Decapod* and *Stomapod*. M. Edwards has, however, shown that all seven pieces are distinguishable in the genus *Squilla* (fig. 8.), although some are largely developed at the expense of others. The first or cephalic segment (1.) is small, of a square shape, and has on each side a semicircular notch (a. a.) on which the collar or pedicle supporting the eye is attached. The second or antennal segment (2.) is larger, but also of a squarish form, and at each of its anterior corners are the ring-shaped epimera (a. a.) on which the basal joints or pedicles of the inner antennæ (fig. 9. b. b.) are affixed: its broad inferior surface or sternum (b.) joins with the following ring, and the episterna (c. c.), stretching backward, assist in supporting the large pedicles of the outer antennæ (fig. 10. c. c.). Both these rings move on each other, and the second on the following one. The largest and most important ring is the third (3.), which forms a large canal containing the stomach; its whole under surface, from being placed in front of the mouth, is called the epistome (a.); its anterior inferior margin joins the antennal piece, and with it forms the sockets for the outer antennæ; its anterior superior margin has attached to it a movable triangular piece which Edwards calls the frontal plate (b.), and overhangs the antennal piece. At the posterior margin of the tube a transverse band (4.), the rudiment of the fourth ring, is attached, and sends a process (a. a.) forward on each side to strengthen its connection: it supports the mandibles. The epimeral pieces of the third ring are enormously developed, and stretch out nearly horizontally like a pair of broad wings (c. c.), and extend backwards much beyond the tergal piece (d.), which, however, itself is continued far beyond the epistome, so that it covers not only the remaining three cephalic, but also the anterior three thoracic rings. The fifth, sixth, and seventh cephalic segments (5. 6. 7.), especially the sixth, seem to be almost entirely their ventral portions, the dorsal portions being deficient, and their place supplied by the large tergal piece of the third segment. The segments of the head are not, as already stated, separated in the *Lobsters* or *Crabs*, and the hindmost four or three segments must be considered as devoid of their tergal portion, of which the place is supplied by the enormous corslet or back-plate held by M. Edwards to be the large development of the dorsal half of the third or fourth cephalic ring. In the *Crayfish*, *Astacus* (fig. 3. A.), and *Lobster*, *Homarus* (fig. 9.), with some others, the corslet is lengthy from before to behind, and in front has a sharp projecting beak (d.), shooting over the ophthalmic segment. The flanks or

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epimeral pieces (*e. e.*) do not stretch outward, as in the *Squillæ*, but bend down on each side as low as the basal joints of the legs, attached, however, except by membrane, to the sternal pieces of the other cephalic and thoracic segments, except around the antennal segment. In the *Crabs* this expansion of the cephalic dorsal piece has more of a horizontal character, and forms a large shield or back-plate of various form in the different members of its group: thus it is either oval with the long axis from side to side, as in the more common kinds, *Corcinus*, *Platycarcinus*, &c. (fig. 4.), or approaching a circular form, as in *Atelecyclus*, or a triangular one, as in *Eurypodius*; and it is also more or less flat or arched from before to behind, or from side to side. The disc of the back-plate is bounded by a more or less sharp edge, and from the under margin a more or less horizontal plate runs inwards, more distinctly from the lateral edges of the shield, and joins with the edges of the breast-plate more or less throughout its whole extent, and which thus forms a very marked distinction between the various kinds of *Crabs* and *Lobsters*. The upper surface of the back-plate is generally marked by slight grooves dividing it into regions, which were first noticed and named by Desmarest; four of them are placed consecutively on the mesial line; the most anterior is the gastric (fig. 5. A. g.), immediately behind the front, covering the stomach, and rather large: the *genital*, or *post-gastric* (h.), follows, is smaller, and generally pointed in front; the *cardiac* (i.) covers the heart, and is usually of an hexagonal form; and the *intestinal* (k.) nearly square shaped, but often scarcely discernible. Two pairs of other regions, separated by those just mentioned, are also, though less distinctly, perceived on the sides of the back-plate; the front pair on each side of the gastric cover the greater part of the liver and the generative organs; these are the *hepatic* (l. l.); the hind pair, one on each side of the cardiac and intestinal regions, form the vaults for the respiratory organs, and are called the *branchial* (m. m.). In the *Lobsters* and other of the *Podopthalmians*, these regions are more or less fully developed. In some of the *Apusian Branchiopods* the cephalic rings spread out into a shield-like back-plate, as in the genus *Apus*; and the same is more easily distinguishable, from the animal's size, in the *King Crab*, *Limulus* (fig. 2.), which belongs to the *Xyphosures*. In the *Daphnoid Branchiopods* the back-plate is divided longitudinally into two pieces, which, dropping down on each side of the animal like the two portions of a bivalve shell, leave space below for the protrusion of the head and limbs, as in *Daphnia*; and the same bivalvular disposition occurs also in the *Ostracoid Entomostracans*, as *Cypris* (fig. 6. a.). In the *Branchioped Branchiopodans*, and in the *Copepodous Entomostracans*, there is neither shield nor shell, but the head is naked, and the same is also the case with the Sucking Crustaceans. In the other Masticating Crustaceans the cephalic rings are not at all divided, but are massed together and form the head, as in *Talitrus* (fig. 5. a.), which has somewhat the appearance of that of a beetle.

The *Eyes* (fig. 3. and 9. a. **.) are supported on pedicles (a.*) on the first cephalic ring in the *Podopthalmous* Crustaceans, as in the *Crayfish* and *Lobster*; but in *Talitrus* (fig. 5. a.) and others, they are sunk into the head, and hence all such are called *Edriopthalmous*.

The *Antennæ* are either two pair or a single pair, but in some of the Suckers, as *Dinemoura* (fig. 1. b. h.), they are merely rudimental, and in others entirely deficient. If two pairs, they are supported by the second and third cephalic ring, and are called inner (fig. 10. b. b.) and outer (c. c.) antennæ. Each antenna consists of two parts, a pedicle of two or three joints, and a terminal stem of a great number of short rings, and gradually tapering towards the tip, as in the *Crayfish* (fig. 3. b. c.). Sometimes, as in *Squilla*, the last joint of the inner pair divides into three setaceous or thread-like stems (fig. 10. b.*); and the outer has springing from its second joint a large appendage (c.*), which is supposed to be analogous to the palp: it exists also in the *Ericthian* Tribe.



The *Mouth* (fig. 11. a.) is bounded in front by a little horny or bony plate, which is the upper lip, *labrum* (b.); and behind by another little plate, commonly bifid, and which is called either lower lip or tonguelet, *labium seu lingula* (c.). Upon each side of the mouth is ranged the masticating apparatus, consisting of true and auxiliary jaws, well seen in the *Crayfish* (fig. 12.). The *true* jaws are three pairs, which are severally connected with the fourth, fifth, and sixth cephalic rings; the first pair, called *mandibles* (a.), are modified so as to cut or break up the food, and are generally furnished with palps (a.*); the second and third pairs, or its *anterior* (b.) and *posterior maxillaries* (c.), resemble horny plates, of which the edges are scolloped and studded with spines and bristles. The *auxiliary* jaws cover over the former, and retain the food to be masticated in permanent contact with them; sometimes there are but a single pair connected with the seventh cephalic ring, as in the *Branchiopods*; sometimes there are two pairs, as in *Sergestes*, or three, as in the *Lobster* (d. e.), and most *Decapods*, in which case those behind the first pair are attached to the first, or to the first and second dorsal ring. These jaws, being used in walking as well as in mastication, are also called *foot-jaws*, and, when fully developed, consist of the essential parts of a leg, like it being made up of consecutive pieces here called the stem (fig. 13. a.), and two appendages, one named the *palp* (b.), which is attached usually to the outer side of the first piece, *coxa*, of the stem, but sometimes to the tip of the second or even to the third; the other, called the *whip* (c.), a slender delicate process, is affixed above, and to the outer side of the stem. The third or most superficial pair of foot-jaws (fig. 3. A.) are, in the *Crayfish* and *Lobsters*, of considerable size, trigonal and tapering towards their tip, with the two inner angles of their first joint and one of the second toothed, and the same angles beset with stiff bristles. In the *Crabs* these jaws have their first two joints (fig. 4. e.) broad and laminar, and, close over the subjacent, jaws like a pair of shutters.

Of the *Thorax*, the seven segments or rings are either perfect or distinct, as in *Talitrus* (fig. 5. b). But when a large corslet or back-plate exists, as in the *Podopthalmians*, the sternal portions of the thoracic segments alone remain, not always, however, separable. Together they form the *sternal shield* or *breast-plate*, which varies in width and shape. In the *Lobster* and *Crayfish* (fig. 3. B. m.) the breast-plate is very narrow, so that the basal joints of the legs are very close to each other; but in the *Crabs* it is of considerable width (fig. 4. B. m.), and the legs widely separated: the five pieces of which it consists may also be noticed as so many transverse bands (o. o. o. o. o.). From the junction of the segments, vertical plates, *apodemata*, are sent into

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the body, forming by their union two rows of transverse cells, one above the other, lodging the muscles which move the legs attached round their apertures. Each thoracic segment supports a pair of *legs*, each consisting of a hip, trochanter, thigh, leg, tarsus and thumb, the latter being movable on the tarsus, and forming with it a pair of nippers. One, two, or three pairs of these thoracic legs, sometimes, as already mentioned, become auxiliary jaws; but all the other pairs not so used are called, from their function, *ambulatory* legs, and are generally provided with palp and whip in the *Podopthalmians*. The first pair of the ambulatory legs in the *Decapodous* Order (so called from having five pairs of these legs) are very considerably larger than either of the others, and in *Lobsters* and *Crabs* are specially called the "Claws" (figs. 3 and 4. A. n.); and it is a curious circumstance regarding the claw-joint, composed of the tarsus and its thumb, that their corresponding edge is in one leg studded with blunt tubercles, whilst in the other it is armed with sharp teeth, probably to provide the animal with suitable instruments for breaking up the different kinds of prey on which it feeds. In the *Hermit Crabs*, *Pagurus*, the second and third pairs of thoracic legs are not clawed, but form long jointed levers with sharp points, by which it is enabled most easily to poize forward the shell in which its naked tail is lodged. The fourth and fifth pair are very small, but clawed, so as to enable the *Crab* to shift itself about in its imperfect covering. The Xyphosurous Subclass, of which is the *King Crab*, *Limulus* (fig. 2. B. and C.), has neither masticator nor sucker, nor has it, properly speaking, any jaws, but the mouth is completely surrounded by ambulatory feet—their tarsal joints all pincer-like—whilst the basal joints, of all (o. o. o. o.), except the first and last pair, are covered with spines on their opposing surfaces, and the last (p.), which are largest, have a somewhat grinding form: hence these five pairs seem to be used as a sort of jaws. The first pair (n.) are attached on each side of a triangular lip (a.), have no spiny structure on their basal joint, and are by some anatomists spoken of as antennæ.

The *Abdomen*, or *Tail*, as it is more commonly called, has both the dorsal and ventral portions of its segments, and forms a cavity, in which are contained only its own moving muscles, and the long slender rectum. It varies much in size, is sometimes short, as in the *Crabs* (fig. 4. B. n.), which are therefore said to form the *Brachyurous* or *Short-tailed* family. It has a flattened form, and shuts down like a box-lid into a corresponding cavity on the under surface of the thorax between the legs: in the male it has a triangular shape, but in the female it is wide and full, and armed with four pairs of double threads to support the spawn. In the *Lobsters* (fig. 3. A. n.) the tail is of great size, hence are they called *Macrourous*; the ventral segments of the rings are flat and horny, and form as it were a chord upon which the ends of the semilunar dorsal segments are fixed: these are of considerable width, and are connected with each other by very loose membranes, so that their motions are very free, and, from the size of their muscles, also very powerful. Upon the under surface of the abdomen are found six pairs of small imperfectly developed legs, which are known as *false legs*, and their principal use seems that of supporting the eggs which the female here carries. The last segment (fig. 3. c.) has a different shape from the others, resembling the point of a broad sword (a.); and on each side of it are two triangular plates (b. b.), each two supported by a common stem, which articulates with the sixth segment: the inner of these two pieces is single, and has its tip, like that of the tip of the seventh segment, ciliated; but the outer consists of two portions, the dentated edge of the larger one overlapping the smaller, which has a delicately ciliated edge. The *Hermit Crabs* are remarkably distinguished by the soft cuticular covering of their abdomen, or tail, which only exhibits rudimentary calcareous rings: it gradually tapers from its junction with the chest to its tip, and has irregularly marked convolutions and depressions, as if in its growth it had acquired the shape of the shell, not uncommonly that of a whelk, in which the animal had inserted it for protection. Little rudimentary legs edged with bristles are observed on its under surface, generally on the left side, and the extremity (fig. 14.) is furnished with a pair of appendages thick and hooked, by which the *Crab* fixes itself in its shell.

The *Sucking* Crustaceans, like the *Sucking* Arachnidans, although at first seeming to have a very differently formed mouth, for the most part possess the same oral parts, although less developed, as the Masticators. The upper surface of *Dinemoura* (fig. 1. A.) exhibits three segments, the anterior (1.) is the head, which has a shield-like form, with the little antennæ (a. a.) projecting from its fore and lateral edges; its posterior margin is hollowed out, and has consolidated perfectly to its middle the first ring of the thorax (2.), behind which is the second (2.*), consisting of a pair of plates, like the wing-cases of beetles, and connected only at their inner anterior points, but overlapping the third ring (2.**), which is a large shield-like piece, deeply cleft at its hinder margin, and entirely concealing the little abdomen: from beneath this, in the female, stretch backwards the oviparous threads (ϕ. ϕ.). The under surface of the *Dinemoura* (B.) is more complicated; the large plane of the head (1.), and the nearly as large one of the fifth thoracic (2.**), seem to be connected by three transverse, somewhat triangular, and overlapping plates, which at first might be mistaken for the under part of the thoracic pieces, but are really formed by the consolidation of the expanded basal joints of each corresponding pair of false feet (o. o. o.), which are two-fingered, and attached near the hinder corner of each band. Of the fourth pair of false feet only the terminal oval and fin-shaped extremities (o.*) are visible, their other joints being overlapped by the basal piece of the third pair. Upon the fifth piece (2.**), the little square abdomen (3.) is seen, and attached to it posteriorly a pair of flattened processes (4. 4.), varying in size in the two sexes. Upon the head (1.), in front of the first pair of false legs, are three pairs of legs (b. c. d.), which are considered to correspond to the foot-jaws of *Masticating* Crustaceans, and are still so called, but in these animals are for the purpose of fixing the animal to its prey: the first and third pair of these have their terminal joints strongly clawed. Between the first pair of foot-jaws is the sucker-like or siphonous mouth (e.), having on each side of it two little processes (f. f.), and rather behind these is a third pair (g. g.). The sucker is formed by the elongation of the lips (C. e. e.*), which are united together about the middle of their length, leaving their tips unconnected and open, and forming near their base on each side a narrow slit, through which the mandibles (B. b. D. b.), each set on a little pedicle, and now reduced to a slender style, can be introduced into the sheath, and projected at the open extremity. On





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the outer side of each pedicle is another piece (g.), which Milne Edwards thinks the rudiment of the first pair of maxillaries in the *Masticating* Crustaceans; and behind and rather to the outer side of these, a pair of styliform processes (h.), the rudiments of another pair of maxillaries. Thus, then, it appears without any very great difficulty all the pieces of the mouth can be accounted for in the *Siphonostomous* Order. In the *Lerneid* Order the well-formed limbs mentioned in the former group are replaced by rudiments or by mere tegumentary lobes, when the animals have attained their full developement. The female attaches itself on some animal, generally a fish, and the male fixes himself beneath her abdomen; the locomotive organs then ceasing to be required, waste away, or are so altered in form as to become useless. Their means of attaching themselves are various. *Tracheliastes* (fig. 15.) has the head (a.) very long, and on each side of its junction with the thorax a still longer process (b. b.) extends forward, and, joining by its tip with its fellow, forms a button-shaped sucking disc (c.); each foot-jaw (d. d.) extends beyond the mouth, and is armed with a strong claw curving outwards, so that, as the animal brings its oral sucker more closely to its prey, the more firmly it becomes fixed. In *Chondracanthus*, the foot-jaws are very similar, but they have not any conjoined lengthened arms, with sucking disc. But the most simple is *Lerneocera* (fig. 16.), in which the head (a.) is only furnished with little symmetrical or mammillary appendages (b. b.).

### Insects.

Insects form a very important class among Articulate Animals. They are characterized by the division of their body into three principal parts, the head, chest, and belly, *caput, thorax, abdomen;* which are less determinately marked in some Insects, as in the *Beetles*, (Mot. Org., Plate 2, fig. 17, A. B. C.) than in the *Wasps* (fig. 18.), in which the chest is connected by one pedicle in front with the head, and by another behind with the belly. They are also furnished with three pairs of legs, and generally with two pairs of wings, all which are attached to the chest. No Insect, however, is thus perfectly formed when first bursting from the egg, in which its animal existence commences, but passes through two stages, during which it in most instances differs remarkably from the form which becomes its own in the third stage. These changes are called the Metamorphoses of Insects, and are said to be *Complete* or *Incomplete* as the animal assumes a more or less perfectly distinct form in its several stages: a familiar instance of the first kind is presented in the *Silkworm*, its chrysalis or grub, and its moth or perfect form; of the second, the *Common Cockroach*, in which the animal proceeds through its primary stages of nearly the same form throughout, except that it does not obtain wings till it acquires its perfect form. The three stages of Perfect Metamorphosis are,—1. the *Larva*, Caterpillar or Maggot; 2. the *Pupa* or Chrysalis, which is remarkable on account of the animal becoming perfectly quiescent and ceasing to feed; but during this state a most wonderful change is going on within its external covering, which leads to the production of 3. the *Imago* or Perfect Insect. In the Imperfect Metamorphosis the larval stage is indicated by the absence of scutellum and wings in the Winged Insects; the second stage has been named by Lamarck the *Nympha*, and is distinguished in Winged Insects by the rudimental appearance of wings, which are fully developed only in their perfect state. There is only space here to observe further, in reference to the imperfect state of Insects, that the body consists of a series of rings, usually thirteen; that some are headless, and that others have heads, as the Maggot of the *House-fly*, and the Caterpillars of the *Butterflies;* that some have not any feet, as the Maggot, and that others have feet, some on the three rings immediately following the head, as in *Cetonia Aurata*, such being specially called *Larvæ;* and some, besides these, six horny legs, having membranous appendages called *prolegs*, on the ventral and anal segments, as in the *Silk Moth:* to such the name Caterpillars, *Erucæ*, is particularly attached.

#### 1. Of the Head.

The general form of the head of Perfect Insects is globular, compressed either from before to behind, or from side to side, and modified so as to assume in different groups of Insects an egg-like, lengthy, obtusely triangular, or other variety of shape. It is divided into several parts, the skull, the mouth, the antennæ, and the eyes.

The Skull, *Cranium* (fig. 17, 19, and 20.), forming the principal part of the head, is a horny case, not separable into pieces, lodging the so-called brain within, and giving attachment to the movable organs of the head without. At the lower and fore part it has one aperture, surrounded by the organs of the mouth; and behind it has another, through which the gullet, vessels, and nerves pass into the chest. Its surface is divided into several regions: the fore part, to which the upper lip is attached, is the lower face or epistome of Latreille, *clypeus* (fig. 19. A. a.), above which is the forehead, *frons* (b.), situated between the eyes (4.); behind it the crown, *vertex* (c.), which is generally flattened horizontally, and descending from its posterior edge, the hind head, *occiput* (d.), very visible in Insects like the *Fly* (fig. 20. B.) and *Bee*, which have the head connected to the trunk by a narrow pedicular neck, but concealed in those like the *Beetles* (fig. 17.) and *Grasshoppers*, of which the back of the head is received into the socket-like cavity of the front of the chest. The under part of the skull, extending back from the chin, is called, by Kirby and Spence, the throat, *gula seu jugulum* (fig. 20. B. e.); but the name *basilar part* of the skull, applied to it by Strauss Durckheim, is preferable. The sides are called cheeks, *genæ* (fig. 20. f.), very distinct in *Flies* and other *Dipterous* Insects, and of which the parts nearest the mouth are the lores, *lora* (f. *); and those next the eyes, the temples, *tempora* (f.**).

The Mouth, *Os*, which is situated at the fore and under part of the skull, usually consists of six pieces, an upper and lower lip, and two pairs of jaws, which together are called oral organs, *instrumenta cibaria, trophi*. They have a peculiar form and arrangement indicative of their use, and are distinguished as biting or masticating organs, *instr. cibaria mordentia seu masticandi*, and sucking organs, *instr. cibaria suctoria:* the *Beetles*, among others, present good examples of the former, and the *Butterflies* of the latter kind of mouth. These organs are attached sometimes to the plane surface of the skull itself, and at other times to a prolongation of it or beak, *rostrum*.

*a.* The *Masticating Mouth* (fig. 19.) has its pieces

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all distinct and free moving. The upper lip, *labrum* (g.), is convex, generally of a rounded but sometimes of a triangular or quadrangular form, and connected by its upper edge to the lower margin of the *clypeus* (a.): in *Halictus*, its depth is increased by the attachment of a little narrow appendage, *appendicula* (fig. 21. g.*), to its lower edge. The lower lip, *labium* (fig. 19. h.), consists of two pieces which are differently named by entomologists, and therefore liable to be confused: Latreille and Burmeister call the inferior and more solid piece the *chin*, and the softer piece which lies within it, the *tongue*. With very good reason, however, Kirby and Spence object to such application of the former term, and consider the under piece as the true lip; but observe, that in many instances this lip consists of two joints, in which case the upper piece is the *true lip*, and the under the *chin*. The true lip (h.) is either triangular, trapezoidal or semilunar, often bifid in front and connected by its hinder edge, either directly with the gula, or indirectly by the chin, *mentum* (h. °), a narrow transverse piece, commonly placed between the base of the mandibles. Within, and on the upper surface of the lip, is attached the tongue, *ligula seu lingula* (h.*), membranous, often protruding beyond the mentum, in which case its under edge becomes horny, and is called the tongue bone, *os hyoideum seu fulcrum*, supporting a pair of feelers: the upper part is a true tongue, sometimes simple, as in the *Grasshopper*, *Dragon-fly*, and other members of the *Orthopterous* and *Neuropterous* Orders; or divided, but closely connected with the chin, as in the *Beetles* or *Coleopterous* Order, or divided into three or four lobes, as in the *Wasps*. The jaws do not move vertically, but horizontally, and are attached on each side of the mouth. The upper jaws, *mandibulæ* (i.), are curved: they are of greater length in the predaceous Insects than in those which bite wood, and of greater strength in the latter than in such as feed on leaves or herbage; their inner surface is armed with processes or teeth, *dentes* (i.*), of various form, according to which they are named,—incisive when having a sharp-cutting edge, as in the *Locust* (fig. 22. A. i.*), cuspid when sharp and conical, as in the *Dragon-fly* (B. i.*), and grinding if their surface is broad, as in *Euchlora*, (C. i.*). The lower jaws, *maxillæ* (fig. 19. k.), are smaller than the upper, but of more complicated structure, each consisting of four pieces: the basal part or hinge, *cardo* (k. 1.), is thin and narrow, is connected with the throat, and stretching out transversely is called by Strauss the transverse branch; at its opposite extremity, and at right angle with it, is the stalk, *stipes* (k. 2.), which is thicker, stronger, and larger, soft and membranaceous beneath, but tougher and harder: it is the dorsal piece of Strauss, and has attached to it the palpiferous scale, *squama palpifera* (k. 3.), on the front edge of which the feeler is borne; the maxillary lobe, *lobus maxillæ seu intermaxillaris* (k. 4.), is perfectly horny, curved, with its inner edge concave, almost always ciliated or furnished with stiff bristles, and its outer resting against the stalk and scale. In the *Hymenopterous* Order, as in the *Bees*, and among the Dung-eating or *Coprophagous Beetles*, as in *Geotrupes* (fig. 23. k. 4.), it is a mere coriaceous scale, varying in form with a ciliated edge. Sometimes this maxillary lobe is thicker, more compact, and divided, as in *Cerambyx*, into an internal and external lobe, *lobus internus* (fig. 25. k. 4.) *et externus* (k. 4 *), of which the former is harder, and the latter more membranaceous, as in the *Musk Beetle*; or the outer lobe assumes a thread-like shape, and is double-jointed, as in *Dyticus* (fig. 19. k. 4.*), whence Illiger considers it as a second maxillary palp. In the *Orthopterous* Order, as in the *Cricket*, *Acheta domestica*, the external lobe (fig. 24. k. 4.) covers the internal lobe (k. 4.*), like a shield or cap, and is therefore called the helmet, *galea*: the same form of the lobe is also observed in the *Dragon-flies*.



Besides the parts already described, the mouth is furnished with two pairs of accessory-jointed organs, the palps or feelers, *palpi*, which have been so named from the presumption of their employment as organs of touch, correspondent with the whiskers, *vibrissæ*, upon the muzzle of the Cats and some other Beasts. Each consists of several pieces or joints, never exceeding six, and of various form, length, and relation to each other. The upper or maxillary feelers, *palpi maxillares* (fig. 19. l.), are movably attached upon the back of each maxilla, at the junction of the upper lobe with the stalk. The lower or labial feelers, *palpi labiales* (m.), commonly arise from the lower lip, as in the *Dytici* and the *Chafers*, but in very many instances from the tongue, as in the *Stag Beetle*; which, however, Westwood denies, and says that the part considered by Kirby and Spence as the tongue is really the lower lip, consisting only of two small membranous threads pencilled with hairs. As to length, the maxillary are generally longest, but not unfrequently they are shorter than the labial palps. Their terminal joint is the most important, and assumes an almost innumerable variety of form in the different kinds of Insects.

*b.* The *Sucking Mouth* exhibits, according to Burmeister, three different forms, the proboscis, the promuscis, and the antlia: in addition to which Kirby and Spence describe the rostrulum and the rostellum; but the latter two are merged by Burmeister into the promuscis. The pieces of the sucking mouth are distinguished by the absence of that free motion of the several parts which characterizes the masticating mouth; but "the sucking organs are (as Burmeister observes) fundamentally the same as the masticating, only transformed, or rather arrested in a lower stage of development, for a careful examination clearly discovers the same identical organs."* Kirby and Spence describe these mouths as "imperfect," because "one part receives an increment at the expense of others, or some parts appear deficient:" but the term "imperfect" is by no means correct, as these mouths, for the purposes intended, are as perfect as masticating mouths; and the increased development of one part above another requisite for the performance of a particular function cannot be admitted to be an imperfection.

1. The *Proboscis* (fig. 26.) belongs only to the whole *Dipterous* Order, among which are the several kinds of *Flies*. It consists of the sheath, *theca*, and the pump, *haustellum*. The sheath consists of two parts, a lengthy canal, and a shorter flattish piece, by which it is partially covered. *Tabanus* (fig. 26.) offers a good example of this mouth in its most perfect form. The canal is produced by the inward curving of the edges of the lengthened labium (h.), which terminates below by expanding into a flapper-like organ, as it is called by Burmeister, consisting of the large and dilatable liplets,

* See his *Manual of Entomology*, translated by Shuckard, p. 59.



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*labella* (h. *°), of Kirby and Spence, who consider them as the true analogue of the proper lip, and the upper part that of the chin. Savigny has, in his engraving of the lower lip of *Tabanus Italicus*, two minute processes, which he thinks are perhaps rudimentary labial palps. The flattish piece on the fore and upper part of this canal is the broader and somewhat convex labrum (g.), here called by modern entomologists the valve, *valvula*, behind which is the opening of the mouth. Sometimes the sheath is bent upon itself, forming either one angle opening forwards, in which is the mouth, or two angles like the letter Z. The haustellum, when retracted, is concealed between the valve and the upper part of the labial canal: it consists of five, four, or two thread-like processes, *setæ*, or even of a single one; the upper two, the knives, *cultelli*, represent the mandibles (i.), the lower two, the lancets, *scalpella*, the lower jaws (k.) and the fifth, when existing, the tongue, or *glossarium* (h.*), between which is the mouth. If there be only two, Kirby and Spence consider these as the lower jaws, and that the mandibles are absorbed in the upper lip; if only one, it is the tongue, and the lower jaws confounded with the lower lip. These haustellar pieces together form the pump, by sliding down and up in the grooved sheath. The whole organ, when not in use, folds beneath the skull, which has generally a corresponding cavity on its under surface to receive it.

2. The *Promuscis* (fig. 27.) is proper to the *Hemipterous* Order, of which *Tettigonia* and *Nepa* are good examples. The lengthened grooved labium (b.) forms the canal, which sometimes is divided into three joints, as in *Tettigonia* and *Nepa*, and in other cases into four or five. Labial palps (fig. 28. m.) were discovered by Savigny on the third joint of the lip of *Nepa Neptunia*. The upper lip or valve (g.) is short and triangular; and it is attached by its base to the under surface of the epistome (a.). In the sheath lie four slender stiff lancets, of which the anterior two are the mandibles (i.), with broad hammer-shaped bases in *Tettigonia* (i. 1.), and their tips (i. 1.*) toothed on both edges, but most deeply on the inner. The posterior two lancets are the maxillaries (k) which speedily run together and form a single stem. The base of each is furnished with a three-jointed palp (l.), although denied by Latreille. The tongue (k.) is trifid in *Nepa*, and at its root is the entrance of the gullet, and sometimes, as in *Tettigonia*, upon each side of the base of the tongue and labium a little membranous process (k.*) exists; these Brandt considers to be the *paraglossæ*.

c. The *Antlia* of Kirby and Spence, or *Spiritrump* of Latreille (fig. 29.), is a most remarkable character of the *Lepidopterous* Order. The small triangular upper lip (h.) has the very short, conical, and slightly-curved mandibles (i.) on each side of its base, and not readily found. The lower jows (k.), consisting of the same parts as in the masticating mouth, have their upper lobes remarkably elongated each into a long cylindrical, transversely wrinkled, hollow filament (k.*), and the two *solenaria*, as they are called, are connected by an anterior and posterior band, which form a third tube (fig. 30. k.**). According to Burmeister the hollow lobes communicate with the forked commencement of the gullet; but Kirby and Spence state that the intermediate tube conveys the fluid aliment into the gullet; and both they and Latreille hold this part to be the analogue of the tongue, here merging into the lower jaws. At the base of each of these lobes a two-jointed feeler is attached (l.). The lower lip (h.) is large, triangular, and horny, frequently divided at its tip, and connected by its base to the stalks of the lower jaws, and having attached to it a pair of large three-jointed and very hairy feelers (m.), which ensheath the maxillary suckers when spirally rolled up and quiescent.



The mouth of the *Bees* and other *Hymenopterous* Insects, as also of the *May-flies*, is, as asserted by Burmeister, merely a more or less prolongation of the masticating mouth. This seems to be proved by the transition from the true *Bees* through the short-tongued genus *Hylæus* to the masticating mouth of the *Wasps*. And in like manner also the mouth of the *Flea*, to which Kirby and Spence apply the term *Rostrulum*, considering it a peculiar form, differs not essentially from the proboscis of *Dipterous* Insects, except in the absence of the liplets. The *Rostellum* of *Lice* has a similar correspondence.

The ANTENNÆ (fig. 31.) are among the most important organs with which Insects are provided. They are a pair, and rest upon the little beds, *toruli* (n.), generally depressions in the crust of the skull, but occasionally long processes situated on each side of the clypeus, as in *Rhipicera* (A. n.), Latr., which might be mistaken for the first joint of the antenna itself. As the position of the toruli varies, the antennæ which they support are correspondently named, and thus are they frontal (B. n.) in *Ptinus*; præocular (C. n.) as in the *Cockchafer*; interocular (D. n.) as in the *Hive Bee*; inocular (E. n.) as in the *Musk Beetle*, or exocular (F. n.) as in *Carabus hortensis*; infraocular (G. n.) as in the *Red Ant*; postocular (H. n.) as in the *Flea*, which is further remarkable for the lodgment of the antenna in a cavity which can be closed by a valve (n.*). The number of pieces or joints of which an antenna consists varies, and it is named accordingly: if there be only a single joint, it is called an exarticulate antenna, as in *Hippobosca* (J.); if two, biarticulate, or three, triarticulate; but if there be numerous pieces, it is called multiarticulate, as, for instance, forty in *Rhipicera mysticina*. Each antenna (C. ♂. o.) is divided into three portions: the first and most distinct piece is the stem, *scapus* (1.), the base of which, received into the bed, is called its bulb, and moves like a ball in a cup; the second, or pedicel, *pedicellus* (2.), is generally very short, and commonly bell-shaped; the third portion, or clavolet, *clavola* (3.), includes all the remaining pieces, whatever be their number; and they are called equal or unequal antennæ, according to the number of joints of which they consist. It must also be observed that not unfrequently the form of the antennæ varies in the sexes, as in the *Cockchafer* (C.* ♂ and ♀); but often to a much more remarkable degree. The length, form, and clothing of these organs exhibit very considerable variety, for which the reader is referred to systematic writers on the subject.

The EYES (fig. 32.) of Insects are of two kinds, compound and simple. Compound Eyes, *oculi* (A. B. p. p.), are placed on the sides of the head, above the mouth; generally there are only a pair, but in some of the *Beetles*, a little process of the clypeus, called the *conthus*, either completely or partially divides each eye, as in the *Dung Beetle*, &c.; or the antenna is attached in the middle of the long ovate eye, and divides it into an upper and lower eye, as in the *Tetraopes* (fig. A. p. p.), among the *Capricorn Beetles*: such therefore seem

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to have four eyes. As to connection, these eyes are generally connected directly to the head by their broad under surface, but sometimes, as in *Diopsis* (B. p.), they are supported on long pedicles. The eyes are convex in each direction, and have either a circular or elliptical base. Each consists of a mass of hexagonal lenses, opposed to each other by their edges, which sometimes are naked, and at other times thickly beset with delicate hairs. The number of these lenses in most Insects is almost beyond belief. Hook counted 7000 in the eye of a *House-fly*, Leeuwenhoek more than 12,000 in that of the *Dragon-fly*, and Geoffroy St. Hilaire calculates that in the eye of a *Butterfly* there are 34,650 of these lenses. In some Insects, however, as the genus *Xenos*, Kirby and Spence state that the number does not exceed 50, and that they are visible to the naked eye. Simple eyes, *stemmata seu ocelli* (C. D. E. q.), are generally three in number, but some *Orthopterous* Insects, as the *Mole-cricket*, and many of the *Hemipterous*, as the *Reduvius* and *Fulgora*, have only two; whilst in the genus *Larra* there is but a single one. When three, the stemmata are usually disposed in a triangular form, generally behind the eyes, as in many *Flies* and in the *Red Ant* (fig. 31. G. q.), but sometimes before, as in the *Dragon-flies*. If there be but two stemmata, they are situated behind the eyes, as in most of the *Bugs*, or on the top of the skull, as in many *Hemipterous* Insects, as *Selenocephalus* (C. q.), or on the face, as in *Centrotus* (D. q.). Generally they are sessile; but sometimes are supported on a foot stalk, as in *Fulgora candelaria*. In the greater number of the *Coleopterous* Insects they are entirely wanting.

II. Of the Trunk.

The trunk consists of two principal parts; the anterior, the chest, *thorax*, and the posterior, the belly, *abdomen*, situated behind it.

The Thorax (fig. 33.), forming the fulcrum upon which the legs and wings move, is very firmly constructed, and consists of three horny rings, to each of which is attached a pair of legs, and to each of the hinder two a pair of wings; or if there be but one pair of wings, these are connected with the middle ring. Although these rings, to which are applied, from their relative position, the names *Prothorax*, *Mesothorax*, and *Metathorax*, are distinguishable, they are not always separable: thus in some Orders the first and second rings are closely united, whilst in others all three are so consolidated that they form one undivided whole. Each ring is generally separable into pieces, one or other of which is more fully developed and distinct; but in the *Aphanipterous* Insects, as the *Flea*, *Louse*, &c., each ring is entire, therefore only an arbitrary division can be made, in reference to its surfaces, and thus the terms back, *dorsum*, sides, *pleuræ*, and breast, *pectus*, are applied to the corresponding region of each ring.

The first thoracic ring, *prothorax* (A.), is made up of four pieces. The *pronotum*, or upper surface (a. b. c. c.), is generally of a squarish shape, its front edge (a.) hollowed out or emarginate, its hind edge (b.) straighter, and its side edges (c. c.), which are either bowed or wavy, often toothed or spined; the upper surface of this piece sometimes exhibits a pectinated ridge, as in the *Acridia*, Latr. From the side edges of the pronotum pass inwards the anterior or lesser shoulder-blades, *omia* (d. d.), a pair of flat and more or less triangular plates, each divided by Audouin into two pieces, of which the larger is his *episternum*, and the smaller attached to its truncated inner apex, and somewhat shaped like a tenter-hook, bis *epimeron*, and forming part of the socket for the *coxa*. The inner edges of the omia receive between them the *prosternum* (e.), which is comparatively narrow, and not unfrequently has a more or less distinct mesial longitudinal ridge, upon each side of which are the sockets, *acetabula*, for the first pair of legs. The upper surface, *i. e.* that facing the cavity of the ring of the prosternum, sends up a pair of little processes, *antefurca* (e.*), or *entothorax*, of Audouin, between the base of which is a hole for the passage of the spinal cord. In the membrane connecting it with the mesosternum is the prothoracic spiracle, a longitudinal gap with a callous edge, into which open all the tracheæ of the fore part of the trunk. The prothorax of *Acrocinus longimanus* is very remarkable for a movable spine which it has on each side, and that of the *Strepsipterous* Insects for a twisted appendage, similarly situated. But the projections observable on this piece in all other Insects are parts of the ring itself, and immovable.

The second ring, *mesothorax* (B.), consists of seven pieces, a single one and three pairs, but each of the latter are sometimes consolidated into a single piece, and thus there may be but four instead of seven pieces. The *mesonotum* (f. f. g. g.) is of a squarish form, arched, occupying the upper part of the ring, and overlapped by the pronotum. It varies considerably in size, depending on the size and power of the pair of wings which it supports: thus in the *Beetles*, in which it only sustains the wing-cases, it is small; in the *Bees* and *Butterflies*, which use the first pair as wings, it is larger; but in *Flies* (fig. 34. f.), and all Insects having but one pair of wings, it is largest, and forms almost the entire upper surface of the thorax. Burmeister speaks of two parts noticeable, though not separable, in the mesonotum, already mentioned, at each anterior angle of which are the sockets, *pteropegæ* (f.* f.*), for the first pair of wings, or for the wing-cases; and stretching back from the middle of its hinder edge, a little process, the *scutellum*,* which is interposed between the attachment of the wings or wing-cases, generally very distinct in the *Beetles*, as a little triangular plate, and in some so large as to cover nearly the whole abdomen, as in the genus *Tetyra*. Audouin and others, however, describe the dorsal surface of the mesonotum as being divided, or rather marked, in most instances into four transverse subsegments, of which the first and last (f. f. g. g.) are narrow, but the second and third broad; the second (f.* f.*) is most important as supporting the anterior pair of wings; and the third (g.* g.*) has the triangular process on its middle, already mentioned as the scutellum. The *scapulæ* (which Burmeister describes as one or two pairs) are the descending extremities of Audouin's second and third subsegments of the mesonotum, and perfect the pteropegæ at their upper and fore part. In such Insects as have the prothorax distinct, as in the *Coleopterous*, the scapula divides into an anterior and posterior portion, *ala scapulæ anterior et posterior*; the former passes into the cavities of the prothorax, whilst the latter forms the sides of the mesothoracic ring, and overlaps the spiracle of this segment. But in those which have the prothorax and mesothorax united, Burmeister says there is no separated scapula, but pecu-

* The division and nomenclature of the several parts of the thorax are those of Burmeister.

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liar pieces, analogous in their situation, doubtless represent them, although with an altered function; and he considers the *patagia* and *tegula* of *Lepidopterous* and *Hymenopterous* Insects as the analogues of the posterior scapular wing, although the former are attached to the mesonotum above, and the latter below the wing. The *mesosternum* (n.) is placed beneath, and is also divided by Audouin into the middle or proper sternal piece (n.), from each side of which rise up three plates, the middle larger one (n.*) the *episternum* (*pleura* of Kirby and Spence), the posterior (n.†) the *epimeron*, which is hollowed to receive the middle coxa, and the anterior very narrow (n. †. †.), the *parapteron* specially for the connection of the wings, and which is very large in *Butterflies* and *Moths*. The *medifurca* (n.**.) is upon the upper surface of the proper sternal piece.

The third ring, *metothorax* (C.) is situated between the former and the belly, and also consists of seven pieces. The *Metanotum* (o o. p. p.) covers the upper part, is of an oblong squarish form, and hollowed in front by the projection of its anterior angles, upon which are placed the sockets, often occupying the entire sides, for the posterior wings; the anterior edge (o. o.) is overlapped by the tip of the scutellum of the mesothorax, which often even covers its middle, upon which a corresponding depression has given cause for that part of the metanotum behind it being named *postscutellum* (p. †.). From the front edge of this ring descends an arching process, *mesophragma* (o. o.), which divides the metathorax from the mesothorax, and from the hinder edge another vertical process, *metophragma* (p. p.), which separates the chest from the belly: this is scarcely visible in the broad-waisted Insects, as *Beetles*, but is largely exposed in those with narrow waist, as in *Hymenopterous* and *Lepidopterous* Insects: in either case a narrow passage is left, through which the alimentary canal is continued. These four parts Audouin considers to be distinct; the mesophragm is his anterior piece, *præscutum*, the metaphragm his posterior one, *postscutellum*; and he divides the intermediate metanotum into other two rings, of which the front one, his *scutum*, is separated into two lateral pieces by the stretching back of the middle of his postscutum, and the hind one, which is the largest, and bears Burmeister's postscutellum, Audouin calls the *scutellum*. The *metasternum* (q. q.) occupies the under part of the ring, is generally square, but sometimes triagonal, hexagonal, or octagonal; either flat, slightly convex, sometimes ridged, and occasionally sending back a lengthened point, beneath the belly, as in the *Water-beetle*: its fore part has concavities perfecting the sockets for the intermediate legs, and behind it has a pair of sockets for the hind legs. The parts of the metasternum described by Audouin are the true *sternum*, consisting of the longitudinal ridge and plate on either side of it, convex in front and concave behind; the *episterna*, one on each side in the convex edge of the former; the *epimera*, narrow pieces on the outer edges of the episterna, and above them the *paraptera* (*parapleuræ* of Kirby and Spence), to which the wings are attached. In the *Hymenopterous*, *Lepidopterous*, *Hemipterous*, and *Dipterous* Orders, the pleuræ and parapleuræ of each side form but a single piece, and in the latter Order are further remarkable for supporting the balancers (fig. 34. φ.).

The Abdomen (fig. 35.), though varying much in shape, is always composed of a series of rings, sometimes connected merely by their margins, and sometimes partially received within each other, but never exceeding nine. This variety of number is sometimes a sexual distinction; thus in all *Hymenopterous* Insects with stings, the male has seven, but the female only six rings. The rings are not always perfect, but sometimes consist of two halves, an upper (a. a.) and a lower (b. b.), united by a delicate membrane: in those Insects which have wing-cases, as in *Beetles* (fig. 17.) and others, the upper dorsal half, or segment of the ring, is softish, whilst the under ventral portion is harder. The margins of the rings are connected by a layer of transverse fibres, crossed at right angles by a second layer, and called *pulmonarium* or *conjunctiva*. In these connecting membranes are placed the spiracles, *spiracula*, *stigmata*, which lead to the respiratory tracheæ. The form of the abdomen is very variable, but if cut through transversely, its section is triangular with the base upwards. The abdomen is in many instances conical, its base resting against the back of the chest. It is said to be *sessile* when its base is joined by the whole of its surface to the metathorax, as is well seen in the *Beetles*; on the contrary it is called *petiolate*, as in the *Wasp* (fig. 18.), when the first abdominal ring, then called the *pedicle*, has a trumpet-like shape, its anterior extremity tubular, and its posterior edge spreading out: this tube is not always simple, but sometimes knotted, and sometimes spread out like a scale. The vent, *onus*, terminates in the last ring of the abdomen, the upper segment being called the *podex*, and the under one *hypopygium*: the cavity immediately above this aperture is the common cavity for the termination of the alimentary canal and reproductive organs, and it has been proposed to call it *cloaca*, from its resemblance to the similar part in Birds. When the segments of the last ring do not close the vent, peculiar thick processes, *nuci*, like a pair of tongs, serve the same purpose, as may be seen in the *Locusts*.

Of the abdominal appendages placed at the extremity of the tail, some are sexual, as the sting, *aculeus*, the borer, *terebro*, the tube, *tubulus*, and the sheath, *vagina*; but others are not, as the forceps, *forcipes*, the fork, *furca*, the styles, *styli*, the cerci, *cerci*, the threads, *filæ*, the bristles, *setæ*, and the siphonets, *siphunculi*.

III. Of the Locomotive Organs.

Wings and legs are supplied to all Insects, excepting a few genera scattered about in almost all the Orders, which are wingless, such as *Lice*, *Fleas*, &c.

The Wings, *alæ* (fig. 36.), are in all winged Insects two pairs, excepting in the *Dipterous* Order, as *Flies*, which have only a single pair. The wings consist of simple compressed bags of epidermis or cuticle stretching out from each side of the prothorax and mesothorax, including between their layers the horny frame-work upon which they are expanded. This frame consists of hollow horny tubes, to which have been indifferently applied the names ribs, nervures, and veins, and to the spaces between them the terms areolets or cells. The tubes generally inclose the tracheæ or air-vessels, but sometimes are themselves blood-vessels. The ribs, *costæ*, are filled with a soft parenchyma, in which Burmeister detected a spiral trachea and a nerve passing from the chest. Wings are of two kinds, 1st, membranous, in the *Neuropterous*, *Hymenopterous*, *Dipterous*, *Dictyotopterous*, and many *Homoptero-Hemipterous* Insects, as the *Dragon-flies*, *Bees*, *Flies*,

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*Cockroaches*, and *Lantern Flies*; and 2nd, horny or parchment-like, to which belong the anterior pair of wings in *Coleopterous*, *Heteroptero-Hemipterous*, *Orthopterous*, and some of the *Homoptero-Hemipterous* Insects, as *Beetles*, *Bugs*, *Locusts*, and *Cicadæ*; such wings, according to their density and structure, are called wing-cases, *elytra*, *tegmina*, and *hemelytra*.

1. *Membranous Wings* (A.) vary considerably in their substance either entirely or partially, in some being dense, in others transparent, and in some there are dense spots upon an otherwise transparent wing. From the base (a.) or part by which the wing is attached to the socket on the thorax, stretch out, diverging from each other, the two ribs, of which the stronger anterior one is specially called the *costa* (b.), or the *radius* of Jurine, and the hinder one the *post-costa* (c.), or the *cubitus* of the same author; both extend towards the apex or outer limit of the wing, a triangular space being left between them, which is the intermediate or *discoidal area* (d.); whilst a narrow space in front of the costa is the anterior or *marginal area* (e.), and a much broader one behind the post-costa the posterior or *anal area* (f.). At one particular point the costa forms a horny expansion, which Latreille calls the *stigma* (a.*), but Jurine names the *carpus* or *punctum*. The post-costa generally divides into branches, which either pass to the margin of the wing without further division, or are subdivided. Transverse branches, *venæ anastomosis*, or *nervi recurrentes*, Jur., pass from the greater stems, and thus numerous small meshes or *areolæ* are produced. This description applies as well to the anterior as to the posterior pair of wings, which are sometimes of equal size, or the posterior pair are generally smaller, but not unfrequently broader and even longer. The surface of the wings is usually smooth, with a few hairs overspreading it, as in the *Dipterous* Order, but in the *Lepidopterous* Insects they are covered with flattened scales.

In *Dipterous* Insects a very remarkable pair of organs exist, called balancers, *halteres* (E.), each consisting of a short thread (a.) attached to the metathorax, and supporting at the tips a small oval or triangular knob (b.). These were considered by Kirby and Spence as replacing the under or second pair of wings, but Latreille held them to be distinct organs. Their attachment, however, to the metathorax, together with the absence of a second pair of wings, are reasons amply sufficient, as Westwood observes, for holding them to be analogues of those organs.

2. Horny or parchment-like wings. (B. C. D.)

*a*. The first pair of wings of *Orthopterous* and *Homoptero-Hemipterous* Insects are called *Tegmina* (B.), and are principally distinguished by their leathery or parchment-like texture, but their costæ and their ramifications are perfectly distinct. The size and shape of the tegmina vary remarkably, sometimes very short, as in the *Mole Cricket*, or very long and slender, as in the *Locust*, or wide and large, as in the *Mantis*. When at rest, the posterior margins of the tegmina sometimes merely touch, as in the *Lantern-fly*; but generally they overlap each other, as in the *Cockroaches*; and this is one of the remarkable distinctions between them and the elytra.

*b*. In the Heteroptero-Hemipterous Insects, as in *Pentatoma*, the first pair of wings, or rather wing-cases, which they really are, are called *Hemelytra* (C.). Kirby and Spence divide the hemelytrum into two parts only, the *corium*, from its leathery consistence, occupying the base; and the *membrana*, which forms the remaining part, and is either coriaceous, membranous, or simply membranous. Burmeister, however, speaks of four parts,—the nail, *clavus* (a.), a longitudinal piece at the inner edge; to its outer side the *hemelytrum* (b.), a triangular horny piece, and often beyond it; the *appendix* (c.), and the *membrana* (d.), between the upper and under layers of which the costæ pass.

*c*. *Elytra*, or perfect wing-cases (D.), belong only to *Coleopterous* Insects, as the *Beetles*, in which, when at rest, they cover the true wings, lying parallel to each other longitudinally upon the upper surface of the abdomen. They are generally very tough, but sometimes soft; hardest in the genus *Doryphora*, Illig.; and softest in *Meloe*, *Telephorus*, &c. Both viewed together, the elytra generally present an elliptical form, often much arched laterally, and arched also from before backwards, with its long axis in the longitudinal axis of the body, and the anterior end truncated where it abuts against the hinder edge of the metathorax; but if separately, each forms an isosceles triangle, of which the outer side is curved. Their anterior edge is the base, its inner angle the scutellar, and its outer the humeral; and about midway between these is the axis by which it articulates with the methorax; in those Insects which have the scutellum very large, the corresponding angle is truncated: its outer edge is called the margin, and the inner, by which it is opposed to its fellow, the suture; when posterior wings are deficient, the sutural edges are so closely connected as almost to defy separation, in which case the elytra are said to be connate; the posterior angle is the apex. The upper surface of the elytra is sometimes smooth, sometimes furrowed, sometimes spined; sometimes it is bristled, and at other times it has scales, as in *Lepidopterous* Insects; upon these depend the brilliancy of the *Diamond Beetles*, and the white marks, like the pollen of flowers, on the green wing-cases of the *Rose Chafer*; the under surface is generally lined with a downy sort of substance corresponding sometimes with the colour of the upper surface.

The position of the wings when at rest is very various; sometimes they are erect, as in the *Butterfly*, in which their upper surfaces are opposed to each other; sometimes they are horizontal, and in the same plane with the body, as in the *Moths*; sometimes incumbent; when lying upon each other they cover the upper surface of the abdomen, as in the *Saw-fly*. Sometimes they remain expanded as well at rest as in motion, thus the *Butterflies*, *Dragon-flies*, &c. Or they may be folded, either longitudinally from the base, like a fan, as in *Orthopterous* Insects, or only from the stigma, as in the *Earwig*, or the whole apex may be folded back from the stigma to the base, as in the *Beetles*. In the *Hymenopterous* and *Lepidopterous* Orders, both pairs of wings are linked together; in the former by a row of minute hooks (F. b. h.) on the anterior margin of the hind wing, which are received into a groove (a. a.) on the posterior margin of the forewing, as in some of the *Bees*; in the latter, among many of the *Crepuscular* and *Nocturnal Moths*, a spine (G. b.) projects from the costa of the hind wing, which is enclosed by a hook (a.) from the under surface of the post-costa of the front wing.

The Legs, *pedes* (fig. 37.), are three pairs attached to the sternal portions of the thoracic segments in

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sockets, *acetabula*. The front pair of legs are considered by Kirby and Spence correspondent to the arms of higher animals, because in some instances they are prehensile organs, as in the *Mantis* (A.), *Nepa* (B.), &c., and also because in other cases they are only partially developed, as in some of the *Diurnal Lepidopterous* Insects,—for example, the genus *Vanessa* (C.); whilst, on the contrary, the posterior two pairs have not the power of holding, but they are always developed. The leg is divided into five parts,—the hip, trochanter, thigh, shank, and foot; of which the corresponding parts of the anterior legs are the collar-bone, trochanter, bladebone, upper-arm, fore-arm, and hand, of Kirby and Spence; the former division is, however, sufficient for all.

The hip, *coxa* (*a*.), is commonly a short conical tube, with its apex truncated; sometimes it is subglobose, sometimes more lengthy, quadrangular, and pyramidal, as in the *Staphylinæ*; sometimes very large and triangular, as in the *Mole-crickets*; and sometimes more flattened, as in the *Dytici*. As regards this member of the several legs, those of the anterior pair are generally shortest and smallest, and of the others longest and largest. Sometimes the coxa is immovably attached to the thorax, as in *Dyticus*, whilst in numerous other instances, among the *Coleoptera*, they move freely in the socket.

The *trochanter* (b.) is generally smaller than the hip, but in *Notonecta* larger: it is sometimes annular, or ring-shaped, as in most *Dipterous* Insects; at others, compressed, obliquely truncated, or prolonged into a lateral point, as in the *Carabi* and *Dytici*. Latreille and Virey are disposed to consider it as part of the coxa; Kirby and Spence, however, on the contrary, state that in *Coleopterous* Insects it is closely connected with the thigh, and that between them there is little motion, though they are unaware of any instance in which it has not separate motion in the coxa.

The thigh, *femur* (c.), is the largest, and generally longest, member of the leg, exceeding the united length of the trochanter and coxa, and often longer than the shank; the thighs of the first pair are generally shortest and smallest, and of the third longest and largest; but this is not always so, for in some, as *Macropus Longimanus*, the first pair are longest and thickest,—in *Onitis Aygulus*, the second pair. The increase of size is generally gradual, but in jumping Insects, as in the *Locust* (D.), the thighs become suddenly and considerably enlarged. As to shape, the femur is usually cylindrical, or, tapering at one end, becomes club-shaped; or it may be angular, flat, very much compressed, globulose, or elliptical. Its connection with the trochanter is sometimes very free, as in *Dipterous* Insects, or much restricted, as in the *Coleopterous*. The edges of the thigh are not unfrequently hairy, or armed with serratures and solitary spines, which Kirby and Spence think are sometimes for the purpose of retaining the shank when folded in its place; in *Phasma flabelliforme*, it spreads out like a hatchet, and in the *Mantis*, broad, semi-elliptical appendages have their edges implanted with a double row of spines.

The shank, *tibia* (d.), is nearly of equal length with the thigh, but more slender; it has a form corresponding with that member, so that if the thigh be conical, the shank bows to fit close to it; or, if it be convex, the shank is concave. As to proper shape, it varies much more than the thigh, and is not unfrequently armed with fringe, long hair, bristles, teeth, or spines, the latter solitary or placed in rows. At the lower end of the shank, around the articular cavities for the foot, some special spines, *calcaria*, *spicula* (d.*), are seen, which are either mere processes of the shank itself, as in *Carabus*, or are movable upon it, as in the *Mantis* (A. d.*), and in some of the *Saw-flies*; these Kirby and Spence consider to be minute toes and fingers, and that their function entitles them to the name *digituli*.



The foot, *tarsus* (e.), follows the shank, and consists of a various number of joints in different Insects: thus a five-jointed foot is called *pentamerous*; four, three, two, or single-jointed, *tetramerous*, *trimerous*, *dimerous*, and *monomerous*. Sometimes in pentameroos and tetramerous feet, as in those of *Cerambyx* and *Coccinella*, the penultimate joint is scarcely discernible; to such is applied the prefix *crypto*, or concealed. When the anterior feet have only four, whilst the rest have five joints, such feet are called *heteromerous*. The joints generally diminish from the first to the penultimate, but the terminal joint again lengthens, and is remarkably distinguished from the rest by a pair of slightly bent, movable hooks, *unguiculi* (e.*), forming a claw, which is either simple or armed with one or many teeth, and assuming a serrated or saw-like form. Between these hooklets, in the *Stag-Beetles* and some others, a spurious claw of similar formation is observed. But in *Hymenopterous* and *Dipterous* Insects, and certain Families of other Orders, in place of these are found soft membranous cushions, *pulvilli* (e.†), by means of which the insect fixes itself as with a cupping-glass, and can walk without difficulty with its back downwards. The number of these vary: sometimes there are two or three, as in the *Tabani*; at other times, as in the *Dytici*, besides two larger, there are a multitude of smaller cushions.

The remaining classes of Invertebrate Animals form the great division of that series to which the name Molluscs, or Molluscous Animals, is applied. They are distinguished from the preceding division by the entire absence of any jointed disposition of their external covering, which, on the contrary, is either soft, consisting of an external skin, lined internally with muscular fibres, as in the *Cuttlefish* and *Slug*, forming a perfect envelope to the whole animal, and, as in the former, furnished with arms or claspers; or the covering is partially of this kind, more specially collected into one particular part of the animal, and forming its foot or locomotive organ, as in the *Snail*, and partially a membranous bag, in which the viscera are contained, and thence called the visceral bag, which is protected from injury by the enclosure of a shell, as in the just mentioned animal. To this covering of the viscera, membranous as in the *Snail*, and all the Molluscs covered with a shell or shells, or with a leathery envelope like the *Ascidiæ*, or skinny, with a muscular lining, as in the *Cuttlefish*, the term *Mantle*, *pallium*, has been generally but loosely applied, for it gives the same name to things very different. Again, the term *Mantle* is equally applied to the membranous-like flaps of skin which turn off from the body of a Mollusc like the *Oyster*, and enclose its sides as the covers include a book, and to the collar by which the visceral bag of the *Snail* is connected with its foot, and still more strangely to the shield-shaped portion of skin which protects the heart and respiratory organ of the *Slug*. It would cer-

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tainly be better to distinguish these very different parts into, first, the *visceral bag* enclosing the intestines, which, in the Naked Molluscs, as the *Cuttlefish*, *Slug*, and the like, consists of skin and muscle, and in those which are contained within a single or univalve shell, as in the *Snail*, is membranous; secondly, the *collar* which surrounds the junction of the visceral bag with the foot, as in the *Snails*, and all Univalve Molluscs; and thirdly, the *mantle* or leaf-like reflections of the membranous visceral bag, observed in the *Oyster* and all Bivalve Mollusca (*i. e.* such as have a pair of shells), and which serve the double purpose of connecting and producing partially, if not entirely, the shells, the interior of which they overspread.

### Cirrhopods.

The Cirrhopodous Molluscs are enclosed in valves, four in some kinds and five in others, and they are either sessile, *i. e.* immovably attached, or peduncular; by the latter form, although attached to a particular spot, they can swing about like a clock pendulum. The *Sessile* Family (*Acamptosomata* of Leach) have their enveloping four valves contained in a short calcareous tube, of which the upper end is open, but the lower closed either by membrane, as in *Coronula* (Cirrhop., Plate, fig. 7.); or by earthy matter, as in *Balanus* (*Ib.* fig. 12.): in either case this base is penetrated by little conical chambers, side by side, into which processes of the mantle pass, and fix the tube to the rock; whilst the movable valves are supported on the upper part of the mantle. In the *Peduncular* Family (*Camptosomata* of Leach), a long pedicle or foot proceeds from the mantle as it shuts up the lower aperture of the five valves, as in the *Barnacle*, *Pentalasmis* (*Ib.* fig. 3.). The pedicle is covered externally with a hard horny cuticle, and contains within a mass of muscular fibres attached by one extremity to the bottom of the mantle, and by the other to its own base, by which it fixes itself. The structure of the mouth (Mot. Org. Pl. 2. fig. 38. n.), which, excepting the large muscle closing the principal valves, is the only organ capable of motion, is in both families, according to Cuvier, very similar, consisting of a horny lip (b.), furnished at each corner with a three-jointed palp (c.), which conceals a pair of jaws with serrated edges (d.); within these a second pair, also serrated (e.), and a little lower a pair of membranous jaws forming a sort of lower lip (f.). Beyond the mouth, and piled upon each other towards the apex of the valvular envelope, are six pairs of double processes of a conical shape (g. g. g. g. g. g.), increasing in length as they ascend, and capable of projection through the aperture of the mantle at the ventral edge of the valves. Each process consists of a short swelling joint, attached by its base to the body of the animal, and projecting from its other extremity a pair of tapering articulated and ciliated processes, which are called feet, and hence the whole Order has been called by Cuvier *Cirrhopodous*. The use of the processes is doubtless, like the arms of the Polyps, to produce currents in the water, by means of which the food should be brought to the mouth. Of late it has been held that these processes are analogous to the foot jaws of the Crustaceans, and the correspondence of their number is adduced as a proof; but the comparison will scarcely hold good, for the jaws of the Crustaceans certainly are not required to produce currents which shall bring their food to them, as they are amply furnished with organs by which to go in search of it.

### Acephals.

This remarkable Class of Molluscous Animals is distinguished by the absence of any head, and by the toothless mouth being almost always concealed within the folds of the mantle, which in different form encloses the animal, and is itself enveloped by an external covering, in one Order gelatinous or coriaceous, and in the others testaceous or shelly. Their food consists generally of minute animals, which are brought to their mouths by the currents in the surrounding water, excited by the motions of the mantle. All the Class are aquatic; and upon the different form and disposition of their branchiæ or gills, their distribution, by Blainville, into Orders depends.

1. The *Heterobranchiate Order:*

These are the Tunicata of Lamarck, who places them between his Radiata and Vermes; but admits that by one section (the *Ascidian*) they are connected with the Molluscs. Cuvier, however, observing that they are provided with a brain, heart, vessels, liver, &c., considers them entitled to a higher place in the animal scale, and has ranged them with his Acephalous Molluscs (a disposition in which Blainville also concurs), but distinguishing them as Shell-less. They exist either as single independent animals, capable of voluntary motion, as the *Salpæ*; or are attached to rocks, seaweed, &c., and are either sessile, *i. e.* fixed by their broad base like *Cynthia* (Mollusc, Pl. Tunic. fig. 1.), or pedicellate, *i. e.* have a long pedicle, as *Clavelina* (fig. 2.), for their attachment. Others, of the genus *Salpa*, are remarkable for their capability of connecting themselves so as to form masses: Lamarck says this is effected by the union of little suckers on the sides of the animals, which, however, is denied by Chamisso, who states that some *Salpæ*, discharged from the parent in long chains, produce a very few distinct individuals of very different form, which in their turn can produce only chains of animals such as those from whence themselves have sprung, and thus an alternate succession of dissimilar beings is produced. But there are some of this Order which are really aggregated together in one common cartilaginous mass, like the polypary of *Alcyonium*. This mass may be either sessile, as for *Distoma* (fig. 4.), or pedicellate, as *Sigillina* (fig. 13.), and in them it is simply indented with cells. But in others, as *Botryllus* (fig. 8.), the central part is hollowed out as a shallow saucer-like cavity, into which the anal apertures of the several animals disposed around it in a circular or oval form empty themselves. Some of these masses float about freely, such as *Pyrosoma*, in which the gelatinous matter assumes the shape of a long hollow cylinder, closed at one end, and having at the other an open circular mouth, which is capable of contraction and dilatation. The animals for which this jelly like cylinder forms a habitation are disposed in its sides at right angles with it, with their mouth external to, and their vent within, the cavity of the cylinder, and by these points alone are the animals connected with the cylinder. Their mouth is also remarkable for being furnished with processes like the arms of Polyps. The external covering of the *Heterobranchiate* Acephals consists of two layers. The external layer varies materially in its character, and is either almost gelatinous, as in *Sigillina*, or cartilaginous, as in *Phallusia*. The internal layer is either muscular throughout, as in



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Zoology. *Cynthia microcosmus*, or membranous, with some muscular bands stretching only over particular regions, as in *Phallusia sulcata*, and in the different kinds of *Salpæ*, or simply membranous, as in *Sigillina Australis*. The two layers have been compared by Savigny to the shell and mantle of bivalve shells; but the analogy, such as it is, of the outer covering is rather to be found in the testaceous tubes of the *Teredo* and *Aspergillum*. Sometimes the two layers of the external covering are connected throughout, as in the *Salpæ*, so that the animal seems to form a tube open at both ends, having its viscera contained within the thickness of the walls of the tube; whilst in the tube itself there is merely the branchia or gill, formed by a doubling of the internal tunic itself. The posterior aperture of the tube has a sort of semilunar valve dropping from its upper edge, which, opening inwards, permits the entrance of the water, but, when the animal tube contracts, closes the aperture and compels its escape by the anterior orifice, in the neighbourhood of which, within, is the mouth. The ejection of the water in front is sufficient to jerk the animal backwards, and this seems its only mode of movement. Of such animals Savigny has formed his *Thalidan* Order. Other animals of this Order are distinguished by the external being widely separated from the internal muscular sac, which is attached to the former merely by its two orifices, the anterior surrounded within by a dentated membranous ring, or by a circle of filaments, and leading to the branchial cavity which occupies a very considerable part of the animal, and the posterior, at which the vent terminates. Such are the *Ascidiæ* of former writers, but which have been divided into several genera by Savigny, who forms of them his *Tethydan* Order.* The motions of the whole Order seem confined to the expansion and contraction of their branchial cavity, which, whilst it changes the water contained in that cavity, also produces currents by which their food is brought to the mouth.

2 and 3. The *Palliobranchiate and Lamellibranchiate Orders*

Include the remaining living Acephals. The name assigned by Blainville to the former Order arises from "the branchiæ being applied to the inner face of the lobes of the mantle." Cuvier, however, considers the pair of fleshy arms in the neighbourhood of the mouth, with which they are furnished, as occupying the stead of a foot, and of sufficient importance to warrant their formation into the distinct Class of Brachiopodous Molluscs; Blainville's arrangement, however, is preferable. The *Lamellibranchiate* Order has its name from the gills, *branchiæ*, being disposed upon the body of these animals like the leaves of a book; the whole of this Order forms Cuvier's Class of Testaceous Acephals, including with it also Blainville's Order *Rudistes*, which consists entirely of fossil shells.

As the animals belonging to these Orders are contained within a pair of shells or *valves*, as they are called in zoological language, they are said to be *bivalves*. It will therefore be necessary to give some account of their form and characters.

The Valves (Conchol. Terms, Pl. 1.) are placed one on each side of the animal, and united together by an elastic ligament, which, to a greater or less extent, connects the inner edge of the upper or *dorsal margin* of one valve with that of its fellow, the whole of which apparatus is called the *hinge*. In some few instances, of which the *Piddock*, *Pholas*, is a good example, the ligamentous connection of the valves is very wide, and covered by a lengthy plate of shell. On the outer side of the dorsal margin is the *beak* or *tip* of the valve, from whence its growth commences and proceeds; it is often called by the French naturalists *crochets*, from having a more or less hooked form, as is well seen in the *Mactræ*. The opposite margin is the lower or *ventral*, and is generally thin comparatively, as indeed is the whole circumference of the valve, excepting at the hinge and its immediate neighbourhood. The anterior end of the valve is called the *oral extremity*, from being near the mouth, and the posterior end the *anal extremity*, from its proximity to the vent of the animal. In most Bivalves the shells shut closely, and no apertures exist; but in others, as the *Razorshell*, *Solen*, both ends are open, the valves together having the shape of a truncated, flattened cylinder; and in others, as *Galeomma*, the ventral margins do not touch. The form of the valves varies considerably: they may be long, as in the *Piddock*, *Pholas* (Conchol. Terms, Pl. 1.), and *Mussel*, *Mytilus*; or deep, as in *Vulsella*; oval, as in *Cytherea* (Pl. *ib.*); rounded, as in the *Scallop*, *Pecten*, (Pl. *ib.*); thick, as in the *Cockle*, *Cardium*; compressed and very delicate, as *Tellina*; cylindrical, as the *Razorshell*, *Solen*; boat-shaped, like the *Ark*, *Arca*; heart-shaped, like the *Cockle*, *Cardium*; wedge-shaped, as the *Wedgeshell*, *Donax*; tongue-shaped, like *Vulsella*; beaked, when the hinder extremity of the shell is much narrower than the front one, as in *Tellina fragilis*; or fan-shaped, when the hinder end is very broad and as it were truncated, as in the *Nacreshell*, *Pinna*; eared, either singly or doubly, when the edge of the shell nearest the beak or summit expands into one ear, as in *Unio delphinus*, or into two, as in the *Scallop*. The external surface of the valves is smooth, as in *Cytherea Chione*; scaly, as in the *Oyster*, *Ostrea*; radiated, like the *Scallop*; ribbed, as the *Cockle*; grooved, as the *Astarte Damnoniensis*; striated, as the *Razorshell*; or tessellated, as the *Reticulated Ark*. According to their correspondence in form, Bivalve shells are said to be *equivalve* when both are alike, as in the *Mussel*; or, when there is but little difference between them, *subequivalve*, as in some of the *Scallops*; but if one valve be flat and the other concave, as in the *Oyster*, they are called *inequivalve*. In the equivalve shells some of the characters are best seen by placing the valves together in their natural position: thus having placed a shell on its ventral edge, and having the dorsal margin above, with the hinge in its mesial line, the most projecting parts on each side of it are called the *nates*, which often rise above the beaks. Often in front of the beaks is a depression, varying in depth and shape, called the *lunula* or *slope*, and behind them another, the *fissura* or *cleft*, of smaller extent than the slope. As to the other external characters on the outer side of each valve, its most swelling part is called the belly, *umbo*; the band along its edge, the limb, *limbus*; and the space between the belly and limb, the disc, *discus*. The internal surface of the valve has a generally correspondent concavity with the convex exterior, but it has also some peculiarities of its own. When the ventral cavity rises into the beak, it is said to be arched, *fornicata*, as in *Isocardia*; when a leaf-like process springs up from its bottom, as in the *Arks*, it is called chambered, *concamerata*; when a

* See his excellent *Mémoires sur les Animaux sans Vertèbre, Partie troisième.*

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lengthened edge descends obliquely from beneath the beak, so as nearly to reach the abdominal edge, as in *Anatina*, then the valve is said to be solidified, *solidificata*; if, as in the *Piddocks*, a curved hooking process stretches from the cavity of the beak into the hollow of the valve, it is appendiculate, *appendiculata*. In the *Terebratulæ* (Pl. *ib. Lamplike-shells*), the right or imperforate valve is furnished with a very remarkable apparatus, consisting of a testaceous loop, commencing near the hinge, stretching into the middle of the shell, and thence turning back upon itself. They are also further remarkable for the aperture near the hinge of the left valve, through which little muscles pass to be connected with the pedicle, which is extended from it like the pedicle of the *Barnacle*. Bivalve shells are closed by the aid of muscular bands which pass from one valve to the other, and their attachments are in pits, more or less deep, in the concavity of the valves; these pits are called *muscular impressions*. Sometimes there is but a single muscle; each valve has then only a single impression, as in the *Oyster*, such are called *Monomyary* valves; or there may be two muscles, one in front and the other behind, as in *Venus*, and many others, such are named *Dimyary*; in some, as *Unio* and *Anodon*, there are three muscles, and the valves therefore *Trimyary*. Two other, but slighter though more extended, impressions exist; the one, indicating the attachment of the edge of the mantle, is the *marginal* or *palleal*; and the other, first noticed by Blainville, and called by him the *abdominal*, produced by the constant application of the foot, and therefore it would be preferable to call it the *pedal* impression, by which also confusion of the term abdominal, as applied to part of the shell's margin, would be prevented. The hinge, *cardo*, a most important part of Bivalve Shells, is variously placed; if near that part of the shell next the mouth, it is called *oral*, as in the *Oysters*; but if upon the back, *dorsal*; and as regards the beak, *præapical* or *postapical*. It may be also either *longitudinal*, as in the *Arks*, where continued along the whole length of the back, and either *straight*, as in those shells; or *curved*, as in *Petunculus*; or angular, as in *Nuculus*. The shell part of the hinge consists of ridges or teeth, and depressions or sinuses, *dentes et fossulæ*, varying in number, and placed upon the inner dorsal margin of each valve, the teeth and sinuses of the one corresponding to those of the other valve. The *primary* or *cardinal* teeth are those immediately below the beaks, and generally of largest size; the *lateral* teeth are smaller and more distant from the front or back of the beaks, and may be distinguished as *præ-* and *post-apical*; if far away from the beaks, they are said to be remote. As to the position of the teeth, it is either vertical, oblique, longitudinal, diverging, or converging; and they are said to be *intrant* when one is received between other two; *alternate* when they cross each other obliquely; *inserted* when the hinge is produced by a reciprocal and inverse disposition in each valve, which is the common arrangement of Bivalve Shells. The teeth themselves are either lamellar, when consisting of longitudinal plates, or short and thick when the contrary; straight or curved; entire or bifid; smooth or striated. The hinge portions of both valves are connected together by a strong elastic ligament of greater or less extent, which, at the same time that it perfects the hinge, and is in its quiescent state, opens the shell by separating the abdominal margins of its valves from each other, which are only again approximated by the action of their connecting muscles; and, therefore, when the animal is dead, its muscular power ceasing, the mere return of the ligament to its quiescent condition opens the valves, or in other words makes the shell gape.



Another remarkable character of all the Acephalous Molluscs, excepting the *Heterobranchiate* Order, is their possession of a true mantle, *pallium* (Mot. Org. Pl. 2. fig. 39), which is really only an elongation of the common tegument of the animal turned backward loosely upon itself: the Mollusc, therefore, besides its close tegumentary investment, is included between the flaps of the mantle like a book within its fly-leaves, and the connection of the external surface of the mantle-flaps with the interior of the valves corresponds to that of the fly-leaves with the book-covers. Such is the simple description of the mantle; but it must be recollected that though it envelopes the animal as far as its dorsal edge before its reflexion upon the valves, yet that in taking this course it must wrap round the muscle or muscles connecting the valves. This simple double-flapped mantle is easily distinguished in the *Oysters* (A.), *Arks*, and *Scallops*. But the mantle is subject to variety of form: sometimes the edges of the valve portions are connected on the abdominal edge, so as to form a sort of tube, open at both ends, as in the *Razorshell* (B.), through the posterior of which the foot of the Mollusc is protruded, and within the anterior lies the mouth. At other times, as in the *Cockle* (C.), the aperture for the foot is towards the middle of the abdominal edge of the mantle. In the *Mussel* (D.) Family the mantle is closed in front and open only behind, through which the foot passes, and also the peculiar horny threads called the *byssus*, by which the animal anchors itself to the rocks: it forms, however, a distinct orifice (a.) for the escape of the excrement; and a thickening in its posterior edge presents the indication of a special respiratory tube. In the Family of *Cockles* (C.) the mantle is elongated posteriorly, either into two distinct tubes of greater or less length, or into a fleshy mass, in which the two tubes are contained; one of these is respiratory (a.), and the other excrementory (b.). The free edges of the mantle are often more or less distinctly lobed or digitated, and sometimes furnished with fringes of *cylindrical* tentacules, which are very distinct in the *Scallops*, and intermingled with little oval plates, each marked with a little speck like an eye, but of which the use is unknown.

### Paracephals.

By this term Blainville designates Cuvier's Gasteropodous and Pteropodous Classes of Molluscs, or all the Orders of Lamarck's Class of Molluscs, except the Cephalopods. The principal characteristic of the Class is, the indistinct development of the head in relation to the rest of the body; although its existence is sufficiently marked by the presence of at least the organs of sight and touch. The variety of their form is very great, as also that of the shells with which nearly the whole of one of the two subclasses into which they are divided is provided. Their motive organs, formed by doublings of the common tegument enclosing masses of muscle, are situated either upon the ventral surface of the animal (that part in the terrestrial kinds which rests on the ground), serving for a foot, as in the *Snail*, whence such are included in the Gasteropodous Subclass, or form little wing-like processes jutting out from the sides of the body, as in *Clio*, on which account all the ani-



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mals similarly circumstanced are included in the Pteropodous Subclass.

A. Gasteropodous Subclass.

The arrangement of this division rests almost entirely upon the conditions of their respiratory organ: the greater number, being aquatic, are furnished with gills, *branchiæ*, whilst the remainder have lungs, *pulmones*, and either live entirely on the earth's surface, or, living in water, are compelled to rise to its surface, in order to inspire fresh air. Hence the Gasteropods are divided into Branchiferous and Pulmoniferous; the *Common Whelk*, *Buccinum undatum*, is an example of the former, and the *Garden Snail*, *Helix hortensis*, of the latter. The Branchiferous Gasteropods are still further subdivided in reference to the position and form of their gills; but further consideration of this subject belongs to the Respiratory Organs.

The whole of Cuvier's Cyclobranchiate, Scutibranchiate, Tubulibranchiate, and Pectinibranchiate Gasteropods, and also both the Aquatic and Terrestrial Pulmonibranchiate Gasteropods, excepting the single genus *Vaginulus*, are furnished with a single or univalve shell, placed upon the dorsal surface of the body, and varying remarkably in its position and size: thus in *Parmacella* it is shallow and small, and on the middle of the back; in *Testacella* (Mollusc, Pl. 3.) also small, and on the hind part of the back; and in *Limax* on the fore part of the back, but remarkable in this genus as being concealed by the skin: in all three genera it forms a vault over the pulmonary cavity. Other and larger shells, as the *Sea Ear*, *Haliotis*, cover almost entirely the whole dorsal surface of the animal. But in a very large proportion of the Gasteropods the organs of nutrition and reproduction are always contained within a capacious conical or tubular shell, and even the head and entire foot can often be retracted within it, as in the *Snail*.

The soft exterior covering of Gasteropods is divided into two distinct parts, the foot and the visceral bag.

The *Foot* (Mot. Org. Pl. 2. fig. 40. a.) consists of a soft expanded tegument, containing within it a large mass of longitudinal muscles passing from one end to the other, and occupying its ventral surface. Its upper surface, when expanded in crawling, forms a longitudinal hollow, which is perfected into a tube by a skinny arch also, and which sometimes overlaps the foot like a fringe. This is generally but too loosely called the *mantle*, from its supposed correspondence to the mantle lining Bivalve Shells; and sometimes designates all the upper or dorsal surface of the animal which can be protruded from the mouth of the shell, but at other times is restricted to the shield-like piece which covers the lung of the Pulmoniferous Gasteropods, and either, as in the *Slug*, includes the shell, or, as in *Parmacella* and *Testacella*, has the little shell resting upon it. From its fore part the head protrudes, and seems, as in the *Snail*, to consist merely of processes of this dorsal tegument. In *Vaginulus*, *Testacella*, *Parmacella*, and *Limax*, the dorsal tegument is perfect; but in most other Gasteropods, it is deficient either far forwards, as in the Trachelipods, or farther back, as in the *Limpets*. Around this aperture is attached

The *Visceral bag* (b.), membranous and varying in form, conical or convoluted, as in the *Limpet* and *Snail*, but distinctly corresponding with the muscular visceral bag of the Cephalopods. Around the junction of the visceral bag with the dorsal surface of the foot, a loose sort of membranous girdle, enclosing the apparatus for secreting the shell, is placed; this is the Collar (Mot. Org. Pl. 2. fig. 40. b.), and analogous to the mantle of Bivalve Shells. When the foot is retracted, it often appears to conceal its edges, and materially diminishes the exposed surface of the foot, as in the *Snails*, in one kind of which, viz. *Pomatia*, it at certain times of the year secretes a layer of shell, which closes the aperture and forms an *opercule* or lid; an organ, however, which in many Gasteropods, as in the *Whelk*, exists permanently on the caudal extremity of the dorsal surface, and when the foot is retracted within the shell turns round over it like a box-lid (Conch. Terms, Pl. 2).

As the Shells of the Gasteropods are a very important part of their organization, it is necessary to give some account of them here. The primary form* of all Univalve Shells is resolvable into that of a simple hollow cone, of which the top is the *tip* or first formed part of the shell, and the *base* the last formed, which continually grows and forms the open area of the cavity of the shell, the walls of which, included between the base and the tip, are called the *body* of the shell; these circumstances are well exemplified in our *Common Limpet*, *Patella Vulgata*. But from this simple condition the cone gradually varies in different kinds of shells, both in the comparative dimensions of its parts and in the direction which its base, or recently-formed part, takes, whence arise the diversified forms of shells. In *Conical* Shells, like that of the *Limpet*, the growth is pretty regular around its entire *margin* or edge, so that, except when the animal is still remaining within it, the fore cannot be distinguished from the hind part of the shell. When, however, the anterior and lateral margin of the shell grows faster than the posterior, although the whole base still continues to spread, an incipient degree of revolution takes place, and, as in *Hipponix*, and in the *Hungarian Bonnet*, *Pileopsis Ungarica*, the tip of the shell seems to drop backwards and downwards, as if inclined to roll around itself. In another form of Univalve Shell, viz. that of the *Spirula* (which, however, is not an Acephal, but a Cephalopod, some few of which have univalve shells), the cone lengthens very considerably, but at the expense of its width, and turns round again and again upon its apex, in the same vertical plane, each turn, however, remaining free and distinct from that which it includes; such are called *Semirevolute* Shells. But if the revolutions of the shell touch each other throughout, and the tip of the shell is actually in the centre, as happens in the *Paper Nautilus*, *Argonauta Argo*, which is also a Cephalopod, then it is said to be *Revolute*. Our common *Planorbis*, which is found in almost every ditch, at first sight appears to be precisely similar to *Argonauta*; but on more close inspection it will be noticed that although the apex is visible on both sides of the shell, yet it really inclines more to one side, consequently out of the centre, and is therefore called a *Subrevolute* Shell. The technical name of the convolutions of these and all other shells is *whorls*, *anfractus*. In most instances, Shells, instead of revolving in the same plane, and acquiring, like those already mentioned, a disc-like form, whence they are called *Discoid*, grow obliquely forwards, from right to left, so that the tip of the shell, whence the growth had commenced, is generally to the right and above, and the aperture to the left

* Many of the different varieties of Univalve Shells are figured in the Plate marked *Terms used in Conchology*, Spiral or Subspiral Shells.

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and below; sometimes, however, the growth is from left to right, and hence the terms *right* and *left*, or *dextral* and *sinistral* Shells. All such Shells are said to form *spires*, which consist of all the whorls between the tip and the aperture of the shell; and in proportion as the whorls are flatter, wider, and shorter, as in the *Helix Algira* (Mollusc, Pl. 3.) or rounder, narrow, and longer, as in the *Scalaria*, the shell is said to be *turbinated* or *spiral*. Sometimes, as in the semirevolute Shells, the whorls are perfectly distinct from each other, of which the *False Wentletrap*, *Scalaria communis*, furnishes an example; but more commonly they rest against each other, as in the *Snails*. Although the whorls may lie against each other in their longitudinal course from the tip to the orifice of the shell, yet is there considerable difference as to their transverse relations: if the whorls incline more towards the outer margin of the spire than to its axis, a central conical cavity is left, which opens at the last whorl, and sometimes reaches up almost to the very origin of the spire; this is called the *navel*, *umbilicus*, of the shell, and varies in extent as the whorls approach or recede from the axis: it is well seen in *Solarium*; but in almost every spiral shell an indication of it is observable in the slight depression at which the margin of the shell's mouth terminates. On the contrary, the whorls sometimes turn so closely around the axis of the shell, that the inner side of the two which touch become consolidated, and form a conical pillar, *columella*, the apex of which rests against the primary whorl, and its base is enclosed within the last; and sometimes even terminates only by running obliquely into the left side of the edge of the mouth. This pillar can only be seen by sawing a shell, for instance any of the *Murices* (Mot. Org. Pl. 2. fig. 41.), longitudinally from its tip to its mouth. Another kind of convolution is observed in some Shells, in which the left side of the mouth is enormously developed, so that the orifice, instead of being more or less circular or oval, becomes a lengthy cleft, extending nearly from one side of the shell to the other, as in the *Cowry*, *Cypræa*, and the apex of the shell is scarcely discernible. Whorls, in the ordinary acceptation of the term, do not exist, but the wall of the shell appears as it were rolled upon itself, lengthening at the same time from end to end, much as if a rectangulo-triangular piece of paper were rolled upon itself from either of its acute angles; such shells Linnæus calls *Convoluted;* but Blainville's term, *Involuted*, is preferable. The incipient form of such kind of shell is well seen in the *Wood Dipper*, *Bulla lignaria*, which does not make one complete involution, and well shows the mode in which the lateral extension as well as the involution takes place. The transition, in all its varieties, of different Shells from one to other of these forms, the difference of shape in the shells themselves, and of their different parts, and the peculiar forms assumed by the margin of the apertures of shells, and the direction which they take, are too numerous to be considered here, although they form very important characters of the several kinds. But in conclusion it must be observed, that the interior of Univalve Shells generally consists of a single cavity, and such are called *Unilocular* or *Monothalamous*. In some, comparatively few, however, the cavity is divided by less or more perfect partitions; such are called *Chambered* Shells; and if the number of the chambers be many, they are named *Multilocular* or *Polythalamous*, of which the shell of the *Pearly Nautilus*, *Nautilus Pompilius*, a Cephalopod, affords a good example. The connection of an Univalve Shell to the animal which it partially or wholly contains is by its collar just within the aperture; but in addition to this, muscular fibres also pass from it to the foot, and, as in the *Snail*, from the lowest or basal extremity of the columella.

Some of the Gasteropods are entirely naked, such as the *Doris*, which swims with its foot upwards, and is moved by the fringed overlapping edge of its dorsal tegument, and by a pair of club-shaped tentacules on the back, which serve as a pair of oars; its branchial apparatus is situated around the aperture of the vent, also on the back, and, being free, presents an example of the *Dorso-nudibranchiate* Order; whilst, on the contrary, the naked branchial fringes which depend between the foot and overlapping dorsal tegument of *Phyllidia* indicate the *Infero* or *Ventronudibranchiate* Order. The *Sea Hare*, *Aplysia* (Moll. Pl. 5. fig. 1.), which has considerable general external resemblance to the *Slugs*, has a long narrow foot, from the front of which projects the head. The development of the lateral borders of the foot is very great, so that they lap over each other at the animal's will, on the dorsal surface of the body, upon which is also a large semicircular valve-like piece of skin, including muscle, arising from its left side only, and often forms a sort of canal, leading the water to the branchial apparatus, which, like the lid of a basket, it almost conceals, and hence arises the arrangement of this and similar animals in the *Tectibranchiate* Order of *Gasteropods*.

B. Pteropodous Subclass.

The few animals belonging to this division are remarkable for the wing-like expansions placed on each side of the narrow neck, which connects the head with the visceral bag: these organs, in *Hyalea* and *Pneumoderma*, are doubtless the locomotive organs, for in the latter a pair of distinct branching gills exist externally on the caudal extremity of the body; and in the former the gills are situated on each side of the body in a cleft of the visceral bag. But in *Clio*, the wings serve both as locomotive and branchial organs, presenting, under the microscope, as Cuvier observes, a very delicate, close, and regular vascular network, connected with the internal vessels and the heart; neither is there any other organ which has any resemblance to gills. Some genera, as *Hyalea* and *Cleodora*, contain shells in the walls of their visceral bag, which others, as *Clio*, have not.

### Cephalopods.

This Class is generally held as the highest of the Molluscs, from its presumed approximation to the Vertebrate Series, in its possession of some internal cartilaginous masses, of which the principal is considered as a rudimental brain-case or skull for the partial protection of the large nervous ganglions supposed to be analogous, to a certain extent, with the brain of Vertebrate Animals. The Cephalopods are so named from having their limbs or arms disposed around the head, pretty much like the petals of a flower around its stamina. The arms, when expanded, stretch not in a radiated form, and the junction of their roots produces a thick muscular ring or cup, its area overspreads with a loose skin, in the centre of which is placed the aperture of the mouth, containing a pair of horny jaws, their shape nearly resembling that of a parrot's beak. The head and arms of the Cephalopod, in its ordinary crawling motions, rest immediately, and more or less

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completely, upon the bottom of the sea in which they live, whilst the body or trunk, consisting of the bag which encloses the viscera, rises above them like a tree-stem above its roots: hence they may be justly described as walking upon their head, a fact necessary to be remembered in connection with the detail of their anatomical characters. But this movement is not the only one they are able to perform, for they have also the power of darting themselves through the water, or swimming, though not in the ordinary acceptation of the term; this motion being effected by the sudden expulsion of the water contained in the cavity enclosing the gills, which jerks the animal backwards.

Cephalopods are divisible into two Orders, which have been named by Owen, in reference to the number of gills, or *branchiæ*, with which they are furnished; hence those having four gills are called Tetrabranchiate, whilst such as have but two are Dibranchiate. The latter, in Blainville's arrangement, are named *Cryptodibranchiate;* but the prefix is useless, as in both Orders the gills are concealed. The former, by the same zoologist, are named *Polythalamacious*, in reference to their lodgment in chambered shells; from which circumstance it is presumed that many fossil chambered shells, of which the inhabitants are unknown, were tenanted by Cephalopods.

The *Tetrabranchiate Order*

Are connected with the Gasteropods by the enclosure of their whole visceral bag within the outermost chamber of their shell, and by the strong connection of the animal itself to the shell by means of a pair of powerful muscles, arising from the cartilage which Owen calls the body of the skeleton. In the *Pearly Nautilus*, the mantle, so called by Owen,* attached to the hind part of the head, before passing back to cover the viscera and form the visceral bag, is produced into a large fold, concave posteriorly, overlapping the involuted convexity of the shell, and sending down on each side a lengthy process, free and unattached, which he considers capable of being expanded over the anterior margins of the shell's mouth. This certainly has great analogy to the collar around the connection of the ventral bag with the foot, as seen in *Snails*. In front of this collar is a very remarkable organ, of a triangular shape, with its apex towards the head: its lateral edges are thin, but its bulk thickens towards its deeply concave base, which faces the involuted convexity of the shell. It is white and fibrous, but Owen thinks it muscular, and that it has considerable analogy to the foot of Gasteropods; and that in creeping, the position of the animal being reversed, it seems calculated to act as its chief locomotive organ. But he adds further, that in a state of rest and retraction it would serve as a rigid defence at the outlet of the shell, which is probably its real use, notwithstanding Rumphius says it is applied to the ground in the progressive motions of the animal. Close to the basal angles of this mantle are the eyes, not sunken, but supported on short pedicles, and thus indicating the position of the head cartilage, their ganglions resting upon its dorsal extremities. Owen describes the head cartilage (Mot. Org. Pl. 2. fig. 42.), as of a triangular form, with its base towards the œsophagus or gullet, and the dorsal angles produced as far as the optic ganglions to form the cephalic processes (a. a.) grooved in front for their reception, and for that of the nervous collar surrounding the œsophagus, the remaining portion of which, passing from one cephalic process to the other, is contained in a membranous canal only, whilst the gullet itself passes through the aperture (c.) between the divergence of the cephalic processes, perfected by the membranous part of the nervous canal. Other two processes, the infundibular (b. b.), pass forwards from the anterior part of the body of the cartilage and diverge into the crura of the funnel. Around the anterior, or (in the animal's natural position whilst moving upon the bottom of the sea) inferior surface of the cartilage are attached the muscles moving the parrot-like beak, which in this animal has the tip of each mandible calcareous; the circular, muscular lip, fringed and surrounding the orifice of the mouth, and having exterior to it four broad flattened labial processes, pierced with twelve canals, in an irregular series along their anterior margin, and each containing a projectile tentacle. External to these and beneath, or, more correctly, before the edges of the mantle or foot, and on each side of the head, are nineteen conical or trihedral processes or digitations disposed irregularly, one upon the other, so that the mass is about two inches in length, although no single one is longer than an inch, and all converging around the orifice of the mouth; they taper towards their tip, each of which is perforated, and gives passage to a projectile annulated tentacule, about a line in diameter, and from two to two and a half inches in length, which, being longer, are only partially lodged in the hollow processes. Besides these, a pair are also projecting from similar hollows in the front of the hood, and four others from immediately beneath its margin, one before and another behind each eye; the latter are, however, distinguished by the circular indentations being deeper on one side than the other. These tentacules, excepting the last mentioned, are considered to be the motive organs of the *Pearly Nautilus* in progression, and perhaps to these may be added the hood. It cannot, however, be doubted that a very material part of their economy is prehension, and that by their means not only does the animal entangle and prevent the escape of its prey, like the Polyps, but also, like the foot-jaws of Crustaceans, apply it closely to the mouth, so that the powerful mandibles may more readily break it up. Between the apparatus of the mouth and the shell, or on the anterior ventral surface, is the funnel, springing up from the ventral bag, of a flattened conical shape, with its base below reaching to the branchio-anal aperture, and its open apex above. It is not a perfect tube, but consists of a pair of triangular, muscular flaps, attached on the sides of the head, and stretching back, increasing in width towards the visceral bag, and sending up on each side processes which reach behind the hood, and in this course are connected with the ventral processes of the head cartilage. Into this cavity the vent empties itself, and through it the water passes in and out of the branchial cavity; but lest the water should be forced in too violently, a curtain-like valve exists, by which the branchial aperture can be closed. The *Nautilus* is connected with its shell by means of a pair of powerful muscles, originating from the whole upper or hinder surface of the cartilage; they are concave towards the visceral bag, and convex on the opposite surface, diverge, and are attached firmly on each side of the interior of the shell, commencing just below the out-stretching of the free processes of the collar by a sharp point, gradually widening and then again con-

* See his excellent *Memoir on the Pearly Nautilus*.

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Zoology. tracting like spindles, and terminating near the ventral margin or outermost partition of the shell. Their attachment, when the shell is removed, is indicated by a thin belt of brown horny matter, the medium of attachment, and, as it were, says Owen, the tendons of the muscles adhering to the shell.

The *Dibranchiate Order*.

The skeleton of the *Octopus*, the largest animal of this section, is least developed: the head cartilage is of an irregular form, its middle pierced by the aperture for the gullet; its hind part contains the so-called brain, and is membranous externally; and laterally it supports a pair of large ganglions; in front it is thicker and harder, encloses the remainder of the œsophageal nervous ring and the organs of hearing, and on either side stretches out a plate, which gradually thins and supports the eyes. From the under surface of the cartilage arise eight long muscular arms of a trihedral form, and gradually tapering towards their tip; upon the base of which are two rows of circular suckers, of various size, and about two hundred and forty to each arm. No contraction indicates the neck, but the visceral bag rises above the head, is large and muscular, and contains a pair of slender styliform cartilages, corresponding to the horny belts of the *Pearly Nautilus*. In front of the visceral bag and near the head is the aperture of the funnel, which is a perfect tube. The general form of both kinds is lengthy, with a narrowed neck, distinctly separating the head from the visceral bag, which is flattened from before to behind, and the connection between which is so long that the head and neck can be retracted and projected from the bag to a considerable extent.

In the *Calamaries* and *Cuttlefish*, the so-called skeleton acquires a more well-defined form, in connection with the horny pen-shaped organ existing in the hind part of the visceral bag of the former, and the calcareous plate occupying the same portion in the latter. The form of the head cartilage in the *Arrow Calamary*, *Loligo sagittata* (fig. 43. A and B.), and in the *Common Cuttlefish*, *Sepia Officinalis* (fig. 44. A. and B.), is very similar, but in the former is deeper from behind forwards, and in the latter widest from side to side; in the *Cuttle* also it is thickest. In shape it resembles a slouched hat without the bead, its concavity towards the mouth, and its convexity facing the visceral bag. A large hole (A. n.) rather behind the centre of the cartilage gives passage to the œsophagus or gullet; and between this hole and the front edge of the cartilage are a pair of little rounded eminences (b. h.) separated from the latter by a deep pit (c.), in which are contained the organs of hearing. The orbits (B. d*. d*.) have their hind part formed by the concave oral surfaces of the cartilage; they are separated from each other by the œsophageal hole (B. n.), of which the lateral edges are produced, so as to deepen the orbits considerably at this part. These raised edges meet at a point both before and behind, and at the ventral junction support a pair of slender lengthy cartilages (a. e.), which in the *Calamary* are small, and stretch into the inside of the membranous part of the orbits, which are so perfected from the edges of the head cartilage. In the *Cuttlefish* these inner orbital cartilages, as they may be called, are of considerable length. Brandt and Ratzeburg describe and figure in the *Cuttlefish* a second pair of orbitar cartilages as attached further outwards, in the neighbourhood of those just mentioned; but it is very doubtful whether they are more than slips of the membranous orbit. The dorsal junction of the œsophageal edges is wider than the ventral, and deeply hollowed (f.) between the orbits to receive the so-called brain, and the edges themselves are hollowed to lodge the lateral nervous branches sent forwards to perfect the œsophageal nervous ring. Upon the entire posterior surface (A. d.) of the head cartilage the bases of the muscular arms are attached, and entirely conceal it. The number of the arms in both *Calamary* and *Cuttle* are four pairs, short in the former, and nearly as long as the body in the latter, their basal surface furnished with a double row of suckers. But besides these, each kind is furnished with a pair of very long arms, of a flattened cylindrical form, and expanding at their tip, each into a lozenge-shaped surface, upon which part only suckers exist. The use of these long arms is probably to fix the animal, like anchors, to a particular spot, whilst the short arms are employed only in applying the food to the horny, parrot-like mandibles which project through the aperture of the circular lip. Among the muscular fibres of the feet, on the anterior or funnel surface of the animal, is a narrow transverse cartilage (C.), having one little process in the centre, and another at each extremity, directed towards the mouth; it probably serves for the further attachment of the long arms. Zoology.

The visceral bag in the *Calamaries* and *Cuttlefish* is of a lengthy form, flattened from behind to before, but more cylindrical in the former; at the upper or tail extremity it is narrowed, and has no opening, but the lower part next the head has a large aperture, of which the thickness of the bag-walls only is the boundary; a loose skin connects the inner margin of this aperture behind with the neck, and in front the bag is connected above the margin with the funnel, and the overspreading of the delicate skin with which the whole bag is invested externally. The visceral bag in front principally consists of a thick muscular structure, but on its posterior surface this is either deficient or very thinly overspreading a shining coat, which lines the whole of its interior cavity: this part of the animal, however, is protected by the existence in the *Calamary* of a horny body, which, from its resemblance, is called the *pen*, and, in the *Cuttlefish*, of a calcareous structure, called its *bone*, which was supposed by Spix to be the analogue of the spine of Vertebrate animals; an opinion long since exploded. In both animals the thin inner layer of the ventral bag forms the front and the common tegument of the sheath in which these parts are contained, and having a not inapt resemblance to a sword-sheath, excepting that it has no aperture by which either organ can be withdrawn. In the *Cuttlefish* (fig. 44.) the lower or cervical extremity of this sheath consists of a thin, wide, and pointed cartilage (D. 1.), which projects beyond the visceral bag: it is very smooth, and has a groove (a.), extending usually from its tip upwards to the skin which connects it at the root of the neck with a corresponding cartilage (e. 2.) on the back of that region, and which has a longitudinal mesial ridge (a.) which plays to a slight extent up and down in the groove of the former, as the head is retracted or protruded. From the upper angles of this second or cervical cartilage, a pair of long, thin, horny processes (b. b.) rise up on each side of the bone-sheath, nearly as high as the tail, forming a sort of seam. These are the analogues of the styliform processes of the *Octopus*, and if any parts are to be considered as

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rudimental vertebral columns, these are the parts, and may be held as indicative of the cartilaginous, tubular, vertebral column, existing in the lowest or cartilaginous fishes. The breadth of the bone-sheath equals the entire breadth of the visceral bag, and is fringed on its edges by a doubling of the skin, so as to produce rudimentary fins. In the *Calamary*, the cervical extremity of the pen-sheath (fig. 43. D. 1.) scarcely extends beyond the visceral bag, and can hardly be said to be distinct from its internal layer which forms the front of the sheath; indeed on withdrawing the pen it appears plane, and only when the pen is contained within it is there indication of unevenness, which is produced by the elevated edges, with the middle longitudinal depression of the flattened bulb-like part of the pen, the depression being also divided longitudinally by a delicate mesial ridge. The back of the sheath also differs from that of the *Cuttlefish* in having a thick muscular covering, which is connected with the muscular fin-like processes springing from each side of the visceral bag near the tail. There is not any appearance of horny seams on the edges of the pen-sheath corresponding with those in the *Cuttlefish*. The cervical cartilage (D. 2.), resting on the back of the neck, is of a brownish-horny colour; it is of a lengthened diamond-like shape, narrowest from side to side, with a deep, longitudinal, mesial ridge (a.). divided by a slight longitudinal groove (a.*), and having on each side a shallow lip (a.†), into which the projecting edges of the pen-sheath are received. This whole cartilage, though much smaller, is considerably thicker than in the *Cuttlefish*, and its connection with the visceral bag longer, so that the retraction and protrusion of the head is greater than in that animal. The two cartilages, viz. the sheath-cartilage and the neck-cartilage, are considered by Meckel as rudiments of the vertebral column, corresponding, he observes, probably not to the whole vertaber, but only to its arch; the analogy, however, can scarcely be admitted, for one principal object of the verteber column, viz. that of protecting the lengthy spinal cord, cannot be effected, as no such cord exists in the Cephalopods. Their probable use appears to be that of furnishing a slide for the retraction and protrusion of the head, and perhaps also to strengthen the connection, otherwise slight, of the head and its prehensile organs to the visceral bag. Upon the fore part of the neck of the *Calamary* and *Cuttlefish* is situated the funnel, in shape like a flattened conical tube deprived of its tip, which forms its orifice just above the root of the anterior arms. Its base is received within the front of the wide mouth of the visceral bag, slightly connected to it by the thin external skin, and by the lining membrane; but more firmly by a pair of cartilaginous ear-like sockets (E.) on the front of the base of the funnel, which receive into their cavities a pair of oblong cartilaginous studs (F.), projecting from the corresponding surface of the visceral bag. Both are more distinct in the *Cuttlefish* than in the *Calmar*, as might be expected from the great extent of the aperture of the visceral bag in the former than in the latter, and therefore requiring a stronger connection.

### OF THE PASSIVE MOTIVE ORGANS OR SKELETON OF THE VERTEBRATE SERIES OF ANIMALS.

The nervous ring or centre perforated by the gullet in the lower Invertebrate Animals, but in those more advanced presenting a posterior and anterior mass or ganglion connected together by lateral branches, and existing either alone or accompanied with other centres, having either a symmetrical or unsymmetrical arrangement, attains its highest development in the Cephalopodous Molloscs in the greater size of the posterior ganglion, which simulates the appearance of a true brain, and is partially enclosed in the cephalic cartilage analogous to the skull. The superior classes of animals now about to be considered are however remarkably distinguished from the Invertebrate by their nervous centres being collected into masses, never so perforated, but invariably contained in a peculiar cavity, consisting of the spine and skull, which, having either cartilaginous or bony walls, isolate them from the other organs and form the essential part of a skeleton, the other parts being superadded for the performance of the variously modified motions requisite for respiration, mastication, and locomotion of various kinds. The existence then of a skeleton indicates a peculiar condition of the Nervous System; and as, with but few exceptions, its essential part, the spine, consists of a set of consecutive, cartilaginous, horny pieces, moving or turning more or less upon each other, and therefore called *Vertebers*, from the Latin *verto*, I turn, all the animals so provided, viz., Fishes, Reptiles, Birds, Beasts, and Man, are included in the VERTEBRATE SERIES.

The existence of a *Cartilaginous Skeleton* in an adult animal alone occurs in the Class of Fishes, and, indeed, in this class only in the very small *Cyclostomatous* group, as the *Hag, Myxine, Lamprey, Petromyzon*, &c.; for in the other so-called *Cartilaginous Fishes* earthy matter does exist often indeed in considerable quantity in many parts of the skeleton, even in the very fins, which, from their assumed cartilaginous structure, have led to the designation of *Chondropterygious* Order, being applied to the Families of *Rays, Sharks*, and *Sturgeons*. In all the other Orders of Fishes, in all Reptiles, Birds, Beasts, and Man, the adult animal has an essentially *Bony Skeleton*, although the quantity of earthy matter contained in it varies materially in different individuals, so that the skeleton in one may have little more firmness or inflexibility than cartilage, whilst in another it may be completely inflexible, dense, and brittle. It is, however, a highly interesting fact, that whatever bony hardness the adult skeleton attains, yet is its first formation cartilaginous, and its density effected by the gradual deposition of earthy matter in this texture.

The Spine and Skull being the essential parts of the skeleton, inasmuch as there are some Fishes which have none other; and as the Skull is by many modern anatomists held to consist of vertebers as much as the Spine, and differing in no other point except its greater capacity, it will be convenient here to point out the parts of which a fully developed verteber consists. The large hole which passes through the verteber from behind to before and forms one ring of the vertebral canal, is called the *spinal hole*, of which the lower arc is encased in the upper part of the circumference of a short cylinder, called the *body:* rising up on each side of this groove, a branch converges towards its fellow till the two meet, and, coalescing, form a single vertical process, called the *spinous*, which, together with the branches, form the *vertebral arch*. At the origin of the branches project outwards on either side the *transverse* processes; and commonly in front of these are a pair of hollowed surfaces projecting rather before the front end of the body, and behind a second more projecting and

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full pair, by means of which the successive vertebers are locked together; these are called, from their situation and use, the *anterior* and *posterior articular* processes. In many animals the lower circumference of the body sends down a pair of branches little distant from each other, which, as they descend, coalesce and form a single *inferior spinous* process, sometimes leaving an aperture between the body and the branches. As the Spine and Skull form the essential part of the skeleton, so the body and arch form the essential part of each verteber, and their conjunction, the vertebral column and canal or cavity, the use of the former being to support and strengthen the latter, and render it less liable to injury. The additional processes, spinous, articular, and transverse, are superadded according to the animal's wants.

### Of the Skeleton of Fishes.

The bones of Fishes differ from those of other Vertebrate Animals in the absence of closed medullary cavities, and in being solid; their exterior, however, is in many instances indented with variously shaped pits and furrows, in which cellular tissue loaded with fat is lodged. This is very apparent in the bodies of the vertebers, and on the skulls of those Fishes especially which have their muscles reddish and so full of grease, as the *Salmon*, that it is impossible to abstract it and prepare a white skeleton; but many white Fish, as the *Herring*, are also similarly circumstanced, and cannot be rendered clean. The junctions of the bones are also peculiar; in the spine the margins of the vertebral bodies are connected by ligament, but a cavity filled with fluid is commonly left between each two. Many bones are united together by interposed cartilage often of extreme tenuity, so that three or four seem at first sight to form but a single bone, as in those parts of the pectoral fins held to be analogous to the fore arm and wrist of higher animals, and also in the junction of some of the bones of the face. The true movable joints, as of the jaws, gill-flaps, dorsal and anal fins, &c., are not, as often said to be, cavities lined with synovial membrane, but are filled with loose cellular tissue loaded with fluid, very like, if not actually, serum. Most of the skull, and many of the face bones, have long jagged points, received into each other; whilst many are connected by simple overlapping edges with scanty, intermediate, cellular tissue, as those of the gill-flap and of the shoulder girdle.

The general form of Fishes is that best suited for rendering their passage easy through the dense medium in which they live, but modified according as their usual resort is nearer the surface or at the bottom of the water. The large and most active Fishes, as the *Mackarel*, *Pike*, *Perch*, &c., which occupy the former station, are compressed, that is, flattened on the sides, and have, independent of their length, their vertical dimensions greatest; their fore part resembles a truncated, compressed pyramid, its base sometimes about the middle of the body, but not unfrequently, especially in swift-swimming Fishes, anterior to this part; thence backwards to the setting on of the tail-fin, the trunk again gradually thins, and in proportion as the length of the hinder part, or tail as it is commonly called, occupies a larger part of the total length of the animal, so is the swiftness of the fish's motions. In the more inactive Fish, which generally keep at the bottom, as the *Gurnards*, the body is less compressed, and has a somewhat four-sided shape; and some are even actually depressed or flattened, and their lateral dimensions very great, as the *Anglers*, which bury themselves in the sand. The flat Fish, as the *Turbot*, *Sole*, &c., have the lateral compression of their bodies and their vertical dimensions greatest of all the Class; they are remarkable for not moving edge-ways, but always lie on one side at the bottom of the water, their under surface distinguished by its whiteness, whilst the upper is characterized by both eyes being situated in it, hence, although in other respects resembling the fish first mentioned, yet is their necessarily unsymmetrical head a most decided character; their motions upwards are effected by a succession of bendings of the head and tail together which are suddenly relaxed, the body being thrown up, just as a curved bow would throw itself forward if suddenly freed from the ligature by which it is bound. Another form of flattened Fish is that of the *Rays*, in which the animal is depressed or flattened from above to below, the lateral dimensions being excessive in proportion to the vertical; this, however, does not really depend on the depression of the body alone, but on the enormous development of the fore limbs or pectoral fins, the motions of which are vertical, and raise the fish upwards in precisely the same way as the downward strokes of the wings of Birds effect towering. Numerous other varieties of form occur in Fishes, but those noticed are sufficient for the present purpose.



The limbs of Fishes are their Fins, upon the substance, structure, and position of which the classification into *Soft-finned*, or *Malacopterygious*, and *Hard-finned*, or *Acanthopterygious*, of the greater number of them is founded. They do not, however, correspond with the limbs of the superior Classes of animals, as organs for the support of the body, which depends on the specific gravity of the fish, graduated for the most part by the contents of the air-bladder. Neither are they to be considered generally as organs of motion, for the tail and its own proper fin is the especial moving organ, sculling the animal along by its quickly repeated, alternately lateral motions, precisely as a boat is sculled along by the oar from its stern; the pectoral fins also serve usually as oars, and, in a few instances, even as feet. But the principal use of the other fins is that of balancing the body and preventing its loss of vertical position. Some of the fins are vertical; such are the *dorsal* or those on the back, of which there may be either one or two, and the *anal*, or that immediately behind the vent. The other fins are pairs, the *pectoral*, placed immediately behind the gill-opening, and analogous to the fore limbs of the other Vertebrate Classes; and the *ventral*, which have only a very slight resemblance to the hind limbs. The ventral fins are sometimes deficient, in which case the Fish is said to be *Apodal*, (without feet or fins,) as the *Eel*; their position on the trunk also varies, and hence the Fish is designated *Jugular* or *Subbrachian* when the ventral fins are immediately beneath the pectoral and connected with their girdle, as the *Cod*; or *Abdominal* when unconnected with the girdle, far behind the pectoral fins, and connected only with the soft parts, as the *Carp*, *Pike*, &c.

1. Of the Spine.

The most simple form of Spine exists in the *Cyclostomatous* or *True Cartilaginous* Fishes, as the *Hag*, *Pride*, *Lampern*, &c., and was held by Meckel to be a higher development of the nuchal cartilage of Cephalopodous Molluscs. A longitudinal vertical section of the Spine of one of these Fishes shows a flattened cylinder of semitransparent bluish jelly



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passing from within the substance of the Skull to the tip of the tail, pointed at both extremities, but tapering more slowly and more completely towards the hinder one, and enclosed in a corresponding fibrous sheath. This gelatinous cylinder was held by zootomists as analogous to the Spine of more highly developed animals, prior to the observations of Cuvier and Von Baer, both of whom have disproved that opinion, and the latter especially has shown, that it merely corresponds with the dorsal chord existing in the chick during the process of incubation, and, like it, forms a frame upon which the vertebral parts are to be modelled, but with this difference, that whilst, in the chick, it is gradually removed as the spine is formed, in these Cartilaginous Fishes it remains throughout life. This gelatinous cylinder or dorsal chord (Skelet. Pl. 1. fig. 1. A. a.) is transparent, and slightly grooved along its upper surface: like the vitreous humour of the eye, it is contained in close cells, but they are irregular and polygonal, and the substance itself not fluid. If divided transversely, a narrow transverse white line appears; if longitudinally, a white flat thread, consisting of fine parallel fibres, which Müller thinks are probably tendinous. It is enclosed in a proper sheath (fig. 1. A. B. b.) consisting of an immense number of circular fibres, and within this a very thin white layer of microscopic granules, inseparable from the jelly itself, but neither membrane nor jelly ever ossifies. The chordal sheath is contained in another (c.), which is the Vertebral sheath, and rudiment of the Spine. In the *Pride, Ammocœtes* (fig. 1.), and the *Hag, Myxine*, it is simply membranous, but is distinctly continuous with the Skull, in which cartilage exists; but in the *Bdellostome*, a very small posteriorly forked cartilage (fig. 2. A. $\phi$.) exists at the junction of the Spine with the Skull, and presents the first appearance of a verteber. The upper surface of the Vertebral sheath enclosing the dorsal chord sends up a pair of thin plates (fig. 1. A. c. *), which unite above, the interspace between which is divided into two canals, the lower one, flat and widest, lodges the Spinal marrow, and is the vertebral canal (d.); the upper one is triangular (e.), and contains a quantity of fat; in front it is tolerably deep, but from the middle of the body to the tail, gradually diminishes in height, and with it the quantity of fat also. These converging plates form the vertebral arch; and from their junction, a thin fibrous membrane (f.), the analogue of spinous processes, springs up, vertically dividing the soft parts from head to tail, and posteriorly receiving upon it the rays of the caudal fin. In these Fishes, from the under surface of the vertebral sheath, descends a thickened ridge, which soon splitting into two diverging layers (g. g.), bound the abdominal cavity on the sides, but behind approach and form a sort of canal through which pass the vessels of the tail.

In the *Lampern, Petromyzon fluviatilis* and *Lamprey, P. Marinus*, the Vertebral sheath has distinct, circular indentations both externally and internally: the lateral ridges become harder and actually bony, and upon the sides of the vertebral canal are placed a row of triangular cartilaginous pieces, connected to each other consecutively, but not united above; these are rudimental, transverse, and spinous processes, and to the more posterior of the latter are the rays of the caudal fin attached.

The transition of the Spine from the simple tubular form to that of a series of short irregular cylinders with jutting projections, or, in anatomical language, into *vertebers*, the characteristics of which are a body and processes, the junction of the latter with the former so disposed as to leave on the dorsal or back surface the spinal hole for the passage of the spinal marrow, is well seen in the *Arctic Chimœra* (fig. 4.). In this animal, Meckel describes the body of the Spinal column as having its fore part, consisting of a very short simple cartilaginous cylinder, closed in front to form an articular surface for the Skull: behind the cylinder, to the extent of three-fifths of the animal's total length, is a succession of cartilaginous rings (c.), about fourteen in the space of an inch, connected together by fibrous tissue, and producing slight circular ridges: to these succeed a second cartilaginous cylinder, of a quadrangular form, and about two-fifths of the animal's length, tapering towards the tail. Within it is lined by a delicate fibrous membrane which encloses the gelatinous cylinder. Upon the upper surface of the cartilaginous cylinders and rings, membranes rise up to form the spinal canal, and transverse processes.*

In the *Sturgeons, Accipenser* (fig. 5.), the dorsal chord becomes more dense rather below its axis, and is penetrated longitudinally by a narrow canal, containing fluid (A. A.): the sheath itself is also very considerably thickened, and divided into distinct pieces, which are in reality the bodies of the vertebers. The arches also over the vertebral canal, and both spinous and transverse processes are distinctly formed; to the former processes are attached the accessory spines (f. *) supporting the superior vertical fins, and to the latter the ribs, which have now assumed their definite character.

The *Ray* Family have the fore part of the Spine long and solid, whilst the hind part consists of short vertebers, diminishing in size to the extremity of the tail. The fore or *branchioscapular* part (fig. 6. a. a.) supports the cartilaginous arches of the gills and the shoulder blades, is very wide at its anterior extremity, having on either side and below the spinal hole the sockets (A. $\pi$. $\pi$.) hollowed from above downwards and facing forwards, for the condyles of the skull, thence it narrows posteriorly, and terminates in four lengthened processes (A. $\rho$.), like two pairs of forks, between the ventral of which the rudimental vertebers are received. From the back of the articular processes, a horizontal flat plate (fig. 6, a. a.), the analogue of a transverse process, runs along each side of the body, overlaps the dorsal extremities of the branchial arches, and is widest upon their hindmost pair, immediately after which the plates suddenly narrow, leaving an angular projection of but little extent, and gradually taper away till they are entirely lost. Upon the dorsal surface, the single vertical spinous plate (b.) rises suddenly from the edge of the spinal aperture, is thence continued back in the mesial line to the vertebers; between it and the transverse processes on either side is left a deep groove, in which lie the muscles raising the head. About the middle of its length, and level with the spinous ridge, stretch out on either side the flat horizontal or scapular processes (d.), much like the end of a paper-knife, upon which are attached the shoulder girdle of the pectoral fins. This branchio-scapular part of the Spine in the *Skate, Raja batis*, merely consists of consolidated vertebers, which is proved by traces of distinct bodies and transverse processes existing in the *Thorn-*

* See Meckel *System der Vergleichenden Anatomie*, vol. i. pt. ii. p. 177.

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back, *R. Clavata*, and still more distinctly in the *Sting Ray, Trygon pastinaca*, thus leading on to the distinct vertebral bodies which exist in the entire length of the Spine of the *Shark*. The *vertebral* or movable part of the Spine of the *Rays* consists of a succession of short cylinders, the rudimental anterior of which are received between the ventral forks of the branchio-scapolar portion, but having escaped from these, form the whole Spinal column below the vertebral canal, and gradually taper to the very tip of the tail. Upon each side of the Spine above the belly, little slips of cartilage stand out, which in the *Thornback, Skate*, and *Sting Ray*, are short, but in the *Torpedo* of greater length, and may be considered either as transverse processes or ribs, but are most probably the former, as in their approach towards the tail they gradually approximate, and at its root coalesce to form a depending process, containing a canal, and having upon their tips some little vertical cartilages which seem to be a rudimental anal fin. Behind this their connection spreads out so as to form a flat surface along the under part of the whole tail. Upon the dorsal surface of the Vertebral column is the groove for the spinal marrow, covered by the arches, which consist of pairs of converging rhomboidal cartileges, and upon or between these rise up the true spinous processes in the *Thornback* and *Skate*, somewhat like the broken tip of a broad-sword, with their points downwards, but in the *Sting Ray* of more distinct and lengthened shape: these processes gradually shorten, and subside opposite the middle of the rudimental anal fin, and near the tip of the tail re-appear as two simple consecutive ridges at some little distance apart, supporting the rays of the two small dorsal fins in the true *Rays*; but in the *Torpedo*, these fins are nearer the belly, and the tip of the tail is surrounded by a distinct caudal fin. The *Sting Ray* is also remarkable for a long flat bony spine which is attached upon the dorsal surface of the tail near to the belly; and the same process is found in the *Eagle Ray, Myliobatis*, which has but one dorsal fin.

In the *Shark* Family the entire Spine is made up of vertebers, of which the first is by far the largest in its lateral dimensions, having spacious articular surfaces on its front for the reception of the condylee of the Skull. The bodies of all the other vertebers (fig. 7, A. B.) are short cylinders and begin to taper from the root of the tail to its tip; they have one conical cavity in front (A. s.) and another behind (b.), of which the points are directed towards each other in the centre of the bone, opposite to which the external surface of the bone is correspondingly contracted. They are connected by ligamentous collars (B. c.), so that a double conical cavity (A. d.) between every two bodies is formed, filled with a watery fluid, and thus is perfected the division of the cylindrical column of the Spine, indicated first in the narrow rudimentary rings of the Vertebral sheath of the *Lamprey*, than in the rings of part of the Spine of the *Chimæra*, and of the whole Spine of the *Sturgeon*, in which latter fish first appeared the longitudinal cavity of the dorsal chord, now in the *Sharks* divided into separate double-coned cavities, occupying the space between the consecutive vertebers, and thus characterising the Spine of Fishes. A shallow groove runs upon the ventral surface of all the vertebers anterior to the tail in which the principal artery passes, and on each side of this is a hole dibbled into the substance of the body receiving the root of the transverse process. These transverse processes posteriorly approach, and bending down more and more, at the root of the tail, coalesce, forming by their junction a canal for the caudal blood-vessels and the inferior spinous processes of the tail, which support the accessory spines connected to the anal fin. Upon the dorsal surface of the vertebral column a deep groove for the spinal marrow passes from the head to the tip of the tail, gradually diminishing in size from the root of the latter. On each side of the groove, deepened by a ligamentous vault rising up from its edges, is a hole corresponding to those below, covered by the lower edge of a little cartilaginous scale above the centre of each verteber, and fixed against the ligament; the space between each two of these pieces is filled by a similar scale, with its point between the bodies of the two adjacent vertebers, and thus each body has on the ligamentous tube above it one whole scale and the halves of other two, one before and the other behind (w. w.). The scales not meeting above, there are not any spinous processes, but in their place a continuous ridge of elastic ligament, upon which, opposite the dorsal fins, accessory spinous processes are ranged in two rows, one above the other, for their support, and the same also are found upon that part of the tail supporting the caudal fin both on its upper and under surface. The *Piked Dog-fish, Spinax Acanthias*, has two remarkable horny spines (fig. 7. z. z.*), one in front of each dorsal fin; but only connected to the ligamentous ridge of the vertebral arches; the first (z.) has behind and attached to it a large triangular cartilage (γ.) with its base running back and parallel with the spine, and upon its hind edge are fixed the accessory spinous processes (f. *) supporting the fin; the second (z.*) has a similar attachment, but in front of it are two squarish cartilages (ĉ.), and behind it a third (γ.), upon which the hind fin rests. Ribs exist in the *Sharks* attached to the transverse processes; these, above the branchial arches, are of considerable length, but are shorter above the belly, and at its hinder part diminish till their disappearance at the tail.

The Spine is bony in all the other Orders of Fishes, except the *Lopho-branchiate*, and they are generally called *Osseous* Fishes, although the quantity of earth contained in the bones is in so different proportions, that in one fish they may be in part or entirely spongy, as in the *Anglers*, whilst, in others, they are nearly brittle as glass, as in the *Carp, Perch*, &c. The Spine consists of distinct pieces with projecting processes, as indicated in the less fully developed skeleton of the *Sturgeon* and *Shark*. The body of the verteber varies in shape, sometimes short, cylindrical, and more or less compressed, sometimes angular. Each end is hollowed into a conical cavity, their points communicating by a small central hole, whilst their bases are connected before and behind with corresponding parts of the adjacent bones, and which is usually their sole connection: sometimes indeed even in these Fishes part of the vertebers are actually consolidated together, as in the *Carp, Cyprinus carpio* (fig. 8. z.), thus recalling the structure of the Spine in the *Chimæra* and *Rays*. The upper groove for the spinal marrow is wide, and the remainder of the canal is formed by the arch of the bone, from the top of which rises up the spinous process. In very many Fishes the arch of the first verteber remains separable from its body throughout life, but in all the others they are early and firmly consolidated. The spinous processes (figs. 8, 9. 11. f. f.) generally increase in length towards the tail, and thence become shorter and shorter; they also generally recline,



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and, as they approximate to the last verteber, become more and more depressed, at last projecting beyond the tip of the spine, and being much compressed laterally and expanded from above downwards, forming a fan-shaped process (f. *) upon which the rays of the tail-fin are articulated. The length of the spinous processes varies considerably; in those Fishes which have little depth, as the *Eel*, *Anguilla* (fig. 10. f.), they are short; in others, as the *Turbot*, *Plaice* (fig. 9. f.), and all the other flat Fish, they are remarkably long, as indeed they are in deep Fish, as the *Dory*, *Zeus*, *File Fish*, *Balistes*, *Butterfly Fish*, *Chætodon*, &c. The dorsal fin is attached to the spinous processes, not however directly but indirectly by other processes which are called inter-spinous (figs. 8, 9, 10, 11, φ.), and are of various shapes, sometimes like carpenters' long nails, sometimes like daggers, the points in all being undermost, whilst their wide upper end has a pulley-like surface, upon which the rays of the fin play. Most commonly there is but one interspinous between every two spinous processes, as in the *Salmon*, *Herring*, *Pike*, &c.; sometimes there are two, as in all the flat Fish, and in many of the deep Fish, as the *Dory*. Transverse processes (figs. 10. 11. h. h.) also exist, and not unfrequently in two sets, the *upper* row stretching outwards and upwards, and elongated by accessory needle-like intermuscular bones; the *lower* standing outwards and downwards, giving attachment sometimes, but not always, to the ribs. In some Fishes those covering the cavity of the belly are very large, as in the *Cod* Family, in which the air-bladder is firmly connected to them. Occasionally having reached the hinder part of the belly, several of them become massed together, and form a large and thick process which descends curving forwards to the lower edge of the body, and which is often but improperly described as the pelvis, as in all the flat Fish (fig. 9. h. *); also in the *Dories*, *File Fish*, &c. Behind the belly they cease, or, as most anatomists say, descend vertically, leaving a space for the passage of the blood-vessels of the tail, and each pair soon coalescing, forms the inferior spinous processes (j.), which are found along the whole length of the tail, reclining more and more till they project beyond the vertebers, and expanding vertically, complete the fan-shaped process, partially formed by the upper spines for the support of the rays of the tail-fin. The articular processes are merely rudimental, and, though they nearly touch, do not overlap.

In the *Lopho-branchiate* Order, the Spine is extremely curious. In the *Sea Horses* or *Sea Needles*, *Hippocampus* (fig. 12), the skeleton of the trunk presents the exact form of the living animal, forming, as it does, a cage-like frame-work, including not only the viscera but the muscles, and simply overspread with skin. Each verteber gives off the spinous and transverse processes, which are shaped like the Roman T; the head of the spinous process is horizontal (A. 1.), those of the transverse processes (2.) vertical, and their upper arms join at a nearly right-angle with the extremities of the horizontal branches of the spinous process, and thus upon the dorsal surface of the animal are formed, by the union of the successive vertebers, a latticed quadrangular canal on each side of the vertical part of spinous processes in which the muscles lie. The ventral cavity is also similarly latticed by the junction of the lower branches of the transverse processes with corresponding little bony ribs (3. 3.), which run inwards to unite with a longitudinal chain of bones (4.) which resemble the breast-bone of Beasts and Man. Behind the belly the vertebers each send from their under surface other T-shaped processes (B. 5.), the branches of which join the lower branches of the transverse processes as far as the end of the Spine, and thus form a second pair of latticed muscular canals. The *Sea Dragon*, *Pegasus* (fig. 13.), has an entirely bony covering, all the interspaces left open in the *Sea Horse* being filled up with solid bone. The flattened and expanded form of its belly part (A.) may not inaptly be compared with that of a Fresh-water Turtle; the dorsal shield (B.) may be readily separated from it, and the Spine (C.) is then seen running beneath the middle line of the former, consisting of a few well developed, and, in comparison with the animal's size, very large vertebers, having very deep and long spinous processes, the tips of which are joined to the dorsal shield, which corresponds to the T head of the spines of the Sea Horse, and the external edges of the shield, which consists of several transverse consecutive bands, each made up of pieces joined by edges toothed like a saw, bend down and join the upraised edges of the lower shield, which is similarly formed; but no distinct transverse processes are visible. The tail, a long square pyramid, consisting of numerous square collars which overlap each other diminishing to the tip, and traversed by the Spine, nearly as in the *Sea Horse*, but its extremity projects beyond the top of the pyramid supporting a little delicate tail-fin. Neither transverse processes nor ribs were distinguishable in the dead specimen examined.

2. Of the Head.

The general form of the Head usually, though not always, corresponds to that of the body: thus in the *Perch*, *Salmon*, *Herring*, &c., it is compressed or flattened laterally, in the *Rays* depressed or flattened from above downwards; but in many Fishes the Head seems to be flat, and the body rounded, as in the *Angler*, *Father Lasher*, &c.; its width however depends principally on the lateral extent of the jaws, the skull itself not being materially expanded. The Head in Fishes consists of the brain-case or Skull, to the hinder, under, and side parts of which the gill-apparatus is attached, before which and below and before the skull is joined the face, containing the organs of sight, smell, and taste, and principally forming the organs of manducation. The cavity of the Skull is in reality but the anterior blind extremity of the canal containing the great nervous centres, and as the spine encloses the spinal marrow, so does it contain the brain; the principal difference consisting in its increased size, which is somewhat club-shaped, the broader part being in front. Some anatomists indeed have held that the Skull actually consists of vertebers; three according to Oken, and four according to Meckel and Bojanus. Of the three, the hindmost, which joins the spine, is the *Auricular*, or the Occipital bone, commonly so called; before it is the *Maxillary*, consisting of the hind part of the body of the sphenoid bone with its temporal plates, and the two parietal bones; and in front is the *Ocular*, formed by the front of the body and the orbitar plates of the sphenoid bone, and by the frontal bone. The *Olfactive* verteber, so named by Bojanus, but proposed by Meckel, has the ethmoid bone for its body and the frontal for its vertebral hole or ring.

The *Pride* presents the most simple form of Skull, viz., a capsule (fig. 1. k.) for the brain, widening gradually forwards from the spinal canal (d.) to its broad blunt termination at the nasal sac (l.). It is of



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a yellow colour, fibrous above and on the sides, and cartilaginous on its under surface (B), with a pair of cartilaginous or bony threads (m.), connected by a narrow membranous isthmus, which is the only representative of the base of the Skull; and having on the upper outer edge of each thread the auditory capsule (n.). The threads diverge behind to receive the point of the spinal column (a.*), and in front stretch forward beyond the brain-capsule (b.), uniting beneath the nasal sac (l.), to form a loop: this part of the threads Müller calls the "palatine frame;" and within the loop is the ashy-grey cartilaginous palatine plate separated from the brain-capsule by the blind end of the nasal sac which reaches back nearly to the tip of the spinal column.

In the *Hag* and *Bdellostome* (fig. 2.), the whole brain-case (B. k.) still appears as the enlarged anterior extremity of the vertebral sheath, is roof-shaped, fibro-cartilaginous above, and fibrous beneath. It rests in the basal part of the Skull, consisting of a bony cartilage (C. o.), on each side of which rest the auditory capsules (n.); a slight concavity behind receives the columnar part of the spine (a.*), and in front the cartilage divides into two short diverging processes (*.), which Müller thinks correspondent with the pterygoid processes of higher animals, and names them accordingly. Each pterygoid process spreads, assuming a somewhat triangular form, with its base above, by which it is connected with a cartilaginous frame-work, of which all before it belongs to the palate, and all behind to the suspensory apparatus of the throat. The palatine processes or frame (m.) stretch forwards, converge, unite in front, and include an oblong oval space, perfected behind by the edges of the pterygoid processes, and containing within it the palatine plate (m. †), which is soft and white in the *Hag*, but in the *Bdellostome* cartilaginous; it is somewhat spoonshaped, the handle stretching forward to the junction of the palate processes, whilst the tip of the bowl is lengthened slightly backwards to reach the base of the skull. In the bowl lies the nasal capsule (B. l.), and on the handle the nasal tube ($\nu$.). On the front of the junction of the palatine branches is attached by its stem a T-shaped bone (B. C. p.), which Müller calls the snout bone, but its position would indicate its analogy to the intermaxillary bone: it forms by its branches the front of the mouth, and supports a pair of tentacules, one at each end. On either side of its attachment to the palate frame, but further out, projects a pointed process (B. q.), each of which bears at its tip a curving fibrous branch, connected at the inner end with the branch of the intermaxillary piece, whilst its outer end curves downwards; they seem analogous to the upper maxillary bones, and together with the intermaxillary they form the upper jaw: on the front of each of these curved bands are borne two tentacules.

The throat-frame or basket, as Müller calls it, from its enclosing the sides of the throat, he considers peculiar to these Fishes. It consists of two diverging cartilaginous processes, which stretch back,—the upper throat process (B. and D. r.) from the base of the pterygoid portion of the skull, and the lower one (s.) being a backward lengthening of the palate process; these are connected by three vertical bulging bands, producing as many apertures, of which the anterior is smallest and the posterior much the largest. From the upper throat processes descend forwards, external to the throat frame, a pair of long cartilages, the tympanal (t.), each having on its tip before an articular surface ($\sigma$.), and behind a long spur (r.); these Müller considers as the great and little horns of the tongue bone; but he is certainly in error, for the larger pieces are closely analogous to the tympanal bones of Osseous Fishes by their position, and also by their articulation with the pieces which he calls the tongue bone, but which are the branches of the lower jaw, notwithstanding his denial of its existence. The lower jaw consists of two pairs of cartilages, the posterior pair (u.) articulate behind with the lower ends of the tympanal bones, and in front with the anterior pair (v.), of which the four extremities are connected with the rudimental upper jaw (q.).



Another very remarkable peculiarity in the *Bdellostome* is the existence of a blind pouch between the columnar portion of the spine and the gullet, which is also formed by a membranous expansion supported by a pair of horizontal cartilages ($\epsilon$.), articulated each by a distinct joint with the palate process just behind the second aperture, and terminating behind in lengthened points; about their middle they are connected by a transverse cartilaginous band ($\zeta$.), from the middle of which stretch back another pair of processes (v.) connected by a second transverse band, having from each corner a little spine (*.), and in the centre a process ($\eta$) with a T-shaped extremity. From the front of the anterior transverse cartilage (v.) a pair of little T-shaped vertical processes ($\theta$) rise up with the transverse branches parallel to the sides of the spinal column. The true tongue bone is what Müller calls the "skeleton of the tongue," very distinct in the *Bdellostome*, but in the *Hag* very delicate, and scarcely discernible; it consists of two pieces, the anterior, formed of two lateral wing-shaped pieces (E. a. a.), with their longitudinal axis from before backwards, and connected in front by a narrow isthmus, which is pointed in front; the posterior piece (b. b.) is semilunar transversely with its convexity forwards, and connected with the wings of the first piece: upon the upper surface of these pieces the two rows of pointed horny teeth are affixed.

In the *Lamprey* (fig. 3.), the Skull is more developed; a cartilaginous bridge (A. a.) passes across the hinder part of the membranous brain-case (w.) from one to the other auditory capsule (x. x.), forming a rudimental occipital bone; from the front of which a pair of diverging branches (b. b.) are sent, which form the sides of the Skull, are connected beneath with the palate-frame, and above include the membranous brain-case (now only unprotected on the upper surface), and in front of it the nasal capsule (y.) with the semilunar cartilage now covering its hind part. The palatine branches (B. c. c.) beneath the brain capsule (w.) enclose an aperture (d.), the nasopalatine; and in front of their loop lengthen into a plate, supporting a broad scoop-like process (e.) with its concavity downwards, which is the analogue of the vomer and forms the muzzle. The free hinder extremities of the palatine branches run back nearly parallel upon the fore and under part of the spinal column (z.), and below the auditory capsule on each side send down a process (C. f.), suspended to which is a short horizontal process (g.): may not the former be the suspensory or tympanal bone, and the latter the rudimentary lower jaw? Before each tympanal another process (h.) descends forwards, and rising again to the front of the lateral cartilage, forming a loop not unlike a kettle handle on each side of the skull; from the lower part of which a short-pointed

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process (i.) stretches, and thus a large curving edge on the front of the Skull is produced, to which is attached the broad ligament connecting the maxillary cartilages forming the frame of the projectile mouth to the Skull. The intermaxillary, or "labral" cartilage (k.) of Müller is a half ring, with its convexity forwards, contained within the lip and connected by the middle of its upper edge with a cartilage (l.), in shape not unlike a human finger nail, having on its root or upper end a pair of somewhat triangular cartilages (m. m.) joined together in the mesial line, and behind with the broad ligament which connects them to the front of the handle-shaped processes of the skull. Each extremity of the intermaxillary bone supports a straightish process (n.), the analogue of the superior maxillary bone, but considered by Müller as simple appendages to his labral cartilage. In the membranous junction of the intermaxillary and maxillary with the nail-like and triangular cartilages is a little process (o.), which, passing backwards, must form the lateral branch of the lower jaw, though Müller calls it the "tongue bone," whilst from between the two a long cartilage (p.) passes backwards, and is the true tongue bone, though called by him the styloid process of the tongue. The close analogy between this and the projectile mouth of the Sturgeon, almost immediately to be described, will prove that this view of the subject is preferable to that taken by Müller.* The circular form of the mouth in these fishes has conferred on them the name of *Cyclostomatous*.

The Head of the *Sturgeon* (fig. 5.) has great external resemblance to that of the long-nosed *Osseous Fishes*. Its longitudinal dimensions are greatest, and its general form that of a four-sided pyramid, of which the muzzle is the tip, and the back of the head the base, with its faces above, below, and on each side. The removal, however, of the bony tegumentary covering shows that, excepting the muzzle, the head has a truncated trigonal pyramidal form, with the base behind, the truncated apex in front, two of the faces lateral and the third superior. Into its base the conical tip of the vertebral column penetrates, and from its upper surface stretch three processes; the middle one (a.) overhangs the adjacent vertebral spines, and the lateral processes (h. h.) which stretch out from each angle are deep, and from them is suspended the shoulder girdle. Between the roots of the latter processes is a gap (c.) above the cavity of the skull, filled up with fat and fibrous tissue, and before it, on each side, a large process (d.) divides the branchial ($\gamma$.) from the orbitar cavity, ($\phi$.) and has beneath a transverse articular surface (e.), concave from behind forwards for the tympanal or suspensory bone. In front of these joints are the thin arching edges of the orbits (f.), bounded before by the base of the muzzle, which is very thick, has the cups of the nostrils (g.) on each side, and tapers to the tip, its under surface being widely grooved throughout its whole length. The basal angle of the Skull (h.) gradually deepens as it continues forwards, separates the orbits, runs into the base of the muzzle, and, curving downwards, terminates by forming a strong keel (h.*), which runs from end to end of the muzzle-groove. A remarkable T-shaped bony plate runs along the basal angle, of which the branches stretch on the front of articular cavities for the tympanal bones, which connect the jaws to the Skull. The tympanal bone consists of two pieces, the upper (j. B. j.) is long and vertical, short, flattened from before to behind, and expanded laterally above, but below in the opposite directions; the lower piece (j.*) is horizontal and trigonal, on its hinder extremity is attached a little depending process (k.) connecting it with the tongue bone (ℓ.), and on its fore part with the jaws. The upper jaw, when at rest, lies beneath the curved base of the skull; it is shovel-shaped, consisting of three pairs of cartilages; the two middle intermaxillary pairs (l. and m.), united by their base, have a diamond shape with truncated angles. The upper angle (l.*) is enveloped in the funnel-shaped gullet, the lower wider angle (m.*) forms the middle of the jaw, the latter angles (m.**), much developed, have large articular surfaces for the tympanal bones behind and above, and smaller ones below for the condyles of the lower jaw. The other pair of cartilages, or rather bones, are the superior maxillary (n.); these are flattened and curved, passing from the fore and outer part of the lateral angles of the intermaxillaries, where, by their expansion, they protect the joint of the lower jaw, to the lower angles of the same cartilages, which they also overlap; they form the sides, and complete the upper jaw. A pair of short, slightly-curved cartilages, united by their inner ends, form the lower jaw (o. o.) of which the other extremities are received into the shallow sockets formed by the intermaxillaries and maxillaries. The protrusion of the jaws and mouth are simply effected by the swinging backwards and forwards of the tympanal bone, the upper end of which moves on the Skull as on a centre, whilst its free lower extremity describes an arc.

The *Ray* Family first present the Skull as an independent part, though connected with the spinal column. In the *Skate* (fig. 6), which exhibits the general form of this Family, the Skull is osteo-cartilaginous, flattened, of an oblong oval shape, and entire, except between the orbits, where it is deficient; the aperture or *fontanel* (f.) being filled up with membrane. The hinder part or *occipital* bone is scooped out transversely, having on each side the swelling ear-capsules (g. g.), now become cartilaginous, and analogous to the petrous bones; between which is the arched aperture of the occipital hole for the entrance of the spinal cord, bounded on each side by the slightly rounded condyles. On the fore and under surface of each petrous bone is a triangular process, on the front edge of which is an extensive shallow cavity for the reception of the tympanal or suspensory bone, which is long, flattened horizontally or depressed in its hinder half, but compressed in front, except its extremity, which widens laterally, forming a rounded articular surface on which the lower jaw moves, and by the depression or elevation of which the jaws are projected or retracted. The sides of the head opposite the fontanel are the superciliary ridges (h.), and undercut, form the orbits, in front of which are the cartilaginous nasal sacs now distinct, and each resembling a cup turned upside down (i.). From between them projects the long pyramidal muzzle or vomer (k.), deeply hollowed on each side throughout nearly its whole length; and from their outer surface, and articulated on it, curves back a strong cartilage (l.) which juts against the great anterior cartilage of the breast fin, to prevent it being drawn inwards when the fin is in action. The under surface of the skull is nearly flat; it is crossed by the two transverse thick and almost bony car-

* Müller's admirable paper, *Vergleichende Anatomie der Myxinoiden, der Cyclostomen mit durchbohrtem Gaumen*, in the *Abhandl. der Kongl. Akad. der Wissens. zu Berlin*, 1834, is well worthy a most careful perusal.

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 tilages of the jaws, convex in front, concave behind, and each consisting of two pieces; upon their corresponding edges the teeth are fixed; the lower or posterior is articulated on the tympanal bone, and upon the former moves the upper jaw or true intermaxillary bones, from each extremity of which a thin cartilage, the analogues of the upper maxillary bones, passes forward to the large cavities of the nasal sacs.

In the *Piked Dog Fish* (fig. 7.), a common example of the *Shark* Family, the head is lengthy, with a pointed, much-depressed muzzle; its upper surface has a large fontanel (e.) between the petrous bones, with the occipital behind and the parietal before. The parietal and frontal bones are perfect as far as the front of the orbits; before which the frontal divides into two broad processes, covering the nostrils, and, separated by a nearly vertical large aperture, opening into the wide and deep groove of the vomer (f.), which runs forwards to the very tip of the muzzle. The occipital region of the Skull is wide, principally from the large size of the petrous bones, between which and the vertebral hole are the articular surfaces for the spine. The temporal pits are bounded posteriorly by the articular surfaces (g.) for the suspensory or tympanal bones, and in front by the posterior orbitar processes (h.), and the orbits in front are separated from the nasal cavities by the anterior orbitar processes (i.). The under part of the Skull behind is flat and wide, but in front forms a keel (k.), upon which the upper jaw moves, and extends forwards to be lost at the tip of the muzzle. The jaws are large and deep, and the lower (l.), which is the larger, has only a very small connection with the large suspensory or tympanal bone, its principal articulation being upon the outer segment of the tongue bone, which occupies almost the whole lower end of the square bone, and is therefore interposed between it and the jaw. The upper jaw has a deep notch in its middle at the junction of its two intermaxillary branches (m.), sometimes increased by the elevation of a short stout process on each side, ascending into the orbits, the intermediate notch receives the keel of the skull: its outer ends are T-shaped, the hinder branch articulating with the lower jaw (o.), from the fore and lateral parts of which ascend, one on each side, a delicate tapering cartilage, the superior maxillary bone (a.), thickest below and pointed above, consisting of two jointed pieces, which run inwards over the upper jaw, when the mouth is closed, but when opened become nearly straight. The *Hammer-headed Sharks*, *Zygæna* (fig. 14.), are remarkable for the peculiar lateral extensions of the Head upon which the eyes are supported. On the under part a transverse groove (a.) receives the upper jaw, and before it the vomer stretches out laterally as a pair of arms (b. b.) to the apertures of the nostrils. In front the bone sends forwards a T-shaped process (b.*), the branches of which are supported at their tips by a pair of styloid processes (c. c.), arising from the sides of a large triangular aperture filled with ligament, on the fore part of the Skull, the rest of which above is bony or cartilaginous, and arched laterally. Between the roots of the styloid processes and the transverse groove, the Skull on each side stretches out into a very long process (d.), widest from before backwards, as it covers the nostrils (ϕ.), and thence tapering and curving slightly forwards towards its extremity, which swells and is hollowed behind (d.*), forming the front and inner part of the orbit. The upper surface of this process is convex in its breadth, and from about the middle of its back-edge passes a flat process (e.), first a little backwards, then directly outwards, and near its termination widens, comes forward overlapping slightly the orbitar extremity of the principal piece, and being cut out (e.*) just behind this junction, forms the posterior part of the orbit, a large space being left between its origin from and overlapping of the principal process which resembles the oval ring of the handle of a pair of scissors: the under surface of the process is concave, in correspondence with its convexity. 

The Head of the *Angel Fish*, *Squatina*, has great general resemblance to that of the *Sharks*, but its upper surface is perfect, except at the base of the very short muzzle, which, with the greater length of the jaws, places the opening of the mouth at the front instead of underneath the head. The upper end of the tympanal bone rests in a long articular cavity, extending from the hind corner of the orbit to the back of the Skull with its concavity from without, inwards, instead of from before backwards, as in the *Rays* and *Sharks*: it, therefore, and with it the lower jaw and tongue bone, can only swing inwards and outwards, instead of backwards and forwards, as in the *Rays* and *Sharks*, consequently the jaws cannot be projected, but simply depressed. Both the intermaxillary and lower jaw bone are very large: each consists of two branches joining at an angle in front; and from the back and upper part of each intermaxillary branch, a short cartilaginous process curves back into a proper chase provided for it in the under part of the orbit. The maxillary bones are very large, and each consists of three branches, one below, joining the side of the lower jaw, and two above, the anterior closely connected with the side of the intermaxillary, and the posterior with the same bone still further back, but its tip also suspended to the under part of the vomer. The two upper and the lower branches of the maxillary are connected together at the angle of the mouth.

The *Angel Fish*, *Sharks*, and *Rays*, from the transverse direction of their mouth, form the *Plagiostomatous* Order of Cartilaginous-finned Fishes.

In the *Osseous* Fishes, the bones of the head are distinct and separable. Their principal development is in relation to the face and gills.*

The Occipital bone (a.) forms the hind part of the Skull, and is vertically of a somewhat square form; it is divisible into several pieces, of which Cuvier describes two single and two pairs of pieces, whilst Meckel and Bakker only enumerate two single and one pair. The principal single and most massive piece is the basilar or inferior occipital, corresponding to the body of a verteber; with its hinder part a large, slightly conical concavity (a. 1.) joins the first verteber; a little sharp ridge on the under and fore part (b. 2.) runs into and fills up the fork-like extremity of the sphenoid; and its upper surface is hollowed to lodge the medulla oblongata. The pair of lateral occipital pieces (a. 3.) ascend one on each side of the basilar hollow, and have at their hinder corner, each a little process (*) resembling the articular processes of the vertebers (whence Meckel calls these "articular bones"); spreading upwards, they converge inwards, and uniting,

* The references correspond to the lettering of the head in Figs. 8, 9, 10, 11, 15, and 15*, of Skeleton, Plate I., except where otherwise expressed.

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form the large occipital hole (φ) for the medulla oblongata; above which they diverge, leave a gap, spread outwards, and each is divided by a transverse suture into two, the lower, called by Cuvier the lateral occipital (a. 3.), joins by its outer edge to the temporal, and the upper, which he calls the outer occipital (a. 4.), joins on the outer and fore part with the parietal, and on the inner and upper part in the gap with the second single or occipital superior piece. This superior piece or crest (a. 5), which Cuvier calls the interparietal, at first upon and between the lateral pieces, is continued forwards between the parietal bones: it often, but not always, forms a crest, sometimes of considerable depth, stretching backwards so as to overhang the spine where it is deepest, and running forwards subsides gradually on the frontal bone.

The Sphenoid bone (b.) consists of two single and two pairs of pieces. The very large single or basilar piece completes, with the occipital, in front of which it is placed, the bottom of the Skull, and projects forwards between the orbits to the nose. Its hinder part (b. 1.) resembles a thick spear-head with its point cleft, and, gradually thinning, underlaps and embraces the slight inferior ridge of the occipital bone; its under surface is rounded, but the upper grooved from behind forwards. Its cranial portion is bounded by a little flat process (1.*) rising on each side and forming the lower boundary of the great anterior aperture of the skull, in front of which stretches forward the palatine process (b. 2.), as the handle of the spear, rounded beneath, but scooped out for some distance from its tip to receive the plug-like extremity of the vomer, and grooved from behind forwards above to receive a cartilage on which is attached the membranous partition of the orbits. Behind and above the flat processes of the basilar piece, the pair of temporal plates or pieces (b. 3.), one on each side, ascend to form the fore and lateral parts of the cavity of the Skull, connected behind with the occipital bone below, and with the petrous bone above, having on its upper, anterior, and outer surface part of the articular cavity for the tympanal bone. Upon each side of the upper and fore part of the basilar, the second pair of pieces, the small orbitar piece or plate, (4.) complete the lateral edges of the great anterior aperture of the skull. The remaining single piece (b. 5.) is short, interposed between the fore and lower part of the temporal pieces, and lying across the basilar; it is probably analogous to the clinoid process, and, if so, may be called the clinoid piece.

The vomer (c.) forms the front of the palate; its lengthened posterior process is received into the hollowed extremity of the sphenoid bone, and its anterior end, thick and rounded, is of a T shape (c. 1.), with curved branches, on the under surface of which teeth often exist.

The bones, considered by Cuvier as analogous to the Ethmoid bone, are a small pair (d.) situated one on each side above the tip of the vomer, and below the anterior extremity of the frontal bone. Their distance from the aperture of the skull is very remarkable, but their connection with the front of the frontal bone and with the vomer seems to bear out Cuvier's opinion.

The Parietal bones, a pair (e.), are of small size, flat, and situated one on each side of the superior occipital bone.

The Frontal bone (f. f.), in front of the parietal and of the superior occipital bone, is of very considerable size, forms the entire vault of the orbits, and stretches as far forwards as opposite the junction of the sphenoid and vomer, to join the ethmoid bone. It consists of one single and two pairs of smaller pieces. The single or middle frontal piece (f.) forms the principal part of the bone, and is of a lengthened triangular form, its base behind connected with the occipital and parietal bones, its lateral edges hollowed (f. 1.) to form the upper ridges of the orbits, and its apex in front truncated (f. 2.): either its upper surface flattened or has a crest continuous with that of the occipital bones; its under surface, at first vaulted in the skull, narrows into a longitudinal gutter, on each side of which are the vaults of the orbits (f. 3.) arched from before to behind. At the hinder extremity of the arch of each orbit are attached, one on either side, the posterior frontal pieces (f.*), principally remarkable for a small hollow on their under surface, assisting to form the articular cavity for the tympanal bone. The anterior frontal pieces (f.**), one at the front of each orbit, are wide and expanded above and behind where attached to the corner of the truncated apex, and have on their fore and outer edge an articular cavity (f.** 1.) for the palate bone; before and below they become smaller but thicker, are connected by their inner edge with the tip of the sphenoid, and before with the vomer and ethmoid bones. Between the principal frontal piece above and the lengthened process of the sphenoid below is a large aperture (ξ.) (which in the recent head is filled up with a ligamentous partition) of greater or less size, according as the ridges forming the central groove between the orbits are more or less deep.

From the posterior frontal bone to the outer edge of the nasal a chain of bones pass forming the lower margin of the large aperture of the orbit; they are the Suborbitar bones (g. g.) of Cuvier, who considers them at most as analogous to the edge of the orbitar portion of the malar bone; Bakker, however, describes them as forming two bones: the larger piece (†), joined in front to the nasal bone, he names Jugal, and the three consecutive pieces, of which the upper joins to the frontal bone, he calls the Zygomatic bone. Sometimes, as in the Gurnards, they form a large plate covering the whole cheek attached behind to the preopercule, and completely concealing the suspensory apparatus of the jaws. By some anatomists they are considered not as true bones, but simply as bony deposits in the dermal tissue of the cheek; their similarity in appearance, however, to that of the opercular pieces in the Gurnards at least, is rather opposed to this opinion.

The Temporal bone (h.) consists of three pieces, of which two are closely connected with the bones of the Skull. The petrous piece (h.), between the occipital articular bone behind and the sphenoidal temporal before, is small and nearly flat, but as it occupies the situation of the petrous part of the temporal bone in Beasts, and partially forms the cavity in which the internal organ of hearing rests, though not contained in its substance, Cuvier thinks it analogous, and therefore calls it the petrous bone. The second piece (h.*), which completes the cranial part of the temporal bone, is the mastoid piece, easily distinguished by a long process (h.* 1.) stretching backwards, forming the outer hinder corner of the Skull, to which is appended the bony girdle supporting the pectoral fins; in front it reaches the frontal bone, with which, and the temporal plate of the sphenoid bone, it forms the shallow socket

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for the tympanal bone (h.* 2.); its upper inner edge joins with the corresponding one of the parietal. The third piece is the tympanal, and from its remaining separate, but connected by a true joint with the Skull, is almost to be considered as a distinct bone, and requires a particular description.

The Tympanal bone (h.**) corresponds to that part of the temporal bone in Beasts and Man which encircles the membrane of the drum of the ear, and also forms beneath the articular surface for the lower jaw. Its mobility on the Skull, as well also as the absence of a drum membrane, no trace of which exists in Fishes, might seem to oppose this analogy, but its resemblance in function and position to that of the bone partially supporting the drum membrane in the Snake, removes all doubt upon the point. The tympanal bone includes the whole bony frame between the articular socket in the skull and the lower jaw, consisting of several pieces, their extremities received into or overlapping more or less each other concur to form a whole. The uppermost or temporal piece (1.), *os symplecticum postremum* of Bakker, is of an irregular, triangular shape, flattened from within outwards, having its apex (a.) above truncated, and forming a long narrow slightly curved articular surface by which it moves on that formed by the conjoined, frontal, temporal, and sphenoid bones; its base is below, the hinder angle (b.) supporting the opercular bone, the middle connected with the preopercular piece, and the front angle (c.) considerably lengthened, and descending to join again with the last named piece externally, and within by a little cylindrical or styloid process (d.) to the tongue bone. On the front of its base are two flat pieces (2. and 3.), considered by Cuvier as corresponding to the body of the tympanal bone, deprived of its articular extremities; the upper one, the *os symplect. supremum* (2.), the lower the *sympiect. medianum* (3.) of Bakker: these both terminate on the broad base of the triangular maxillary piece (4.), or jugal bone of Cuvier, the apex of which in front forms the articular surface (a.) for the lower jaw; the lower edge joins the front of the preopercole, and the upper with the pterygoid bone. The lower or preopercular piece (5.), *os symplect. anterius* of Bakker, is the largest of all, irregularly flattened from within outwards, of a curved shape, connected above with the temporal piece; on its hinder lower convex edge, with the three pieces (6. 7. 8.) of the gill-flap, on the upper part of its concavity again with the temporal piece, and below with the maxillary piece. The junction of these several tympanal pieces together forms an irregular semi-lunar bone, the arc of which is formed behind and below by the temporal preopercular and maxillary pieces, and the chord by the upper and middle symplectic pieces, or body connecting the temporal and maxillary together; hence results a very strong fulcrum, upon which the lower jaw and the gill-flap move.

The Pterygoid bones (j.), a pair, answer to the unjoined pterygoid plate of the sphenoid in the human fœtus, and remains distinct in adult Birds; each consists of a pair of thin plates running forwards and inwards from the upper edge of the maxillary piece of the tympanal to the hinder end or base of the palate bone, serving as a stret which thrusts the palate bone forwards, at the same time that it prevents the maxillary extremity of the tympanal being drawn too closely to the sphenoid.

The Palatine bones (k.), a pair, are of a somewhat triangular form, thin and slightly concave above and without, and convex below and within; each base joins the pterygoid bone; its upper edge rests against the side of the junction of the sphenoid and vomer, and below the anterior piece of the frontal bone; its apex sends a little beak-like process (k. 1.) forwards, and overhanging the ethmoid bone, joins the top of the inner extremity of

The Superior Maxillary bone (l.), which is merely a simple curved flat piece, descending in the upper lip behind the corner of the mouth upon the outside of the lower jaw; and as it often supports a barb or beard, it is not unfrequently called the Labial or Mystacal bone.

The Nasal bones, a pair (m.), are of small size, in front of the anterior frontal, and between the palatine bones.

The Intermaxillary bones, a pair (n.), form the front of the upper jaw, and are attached to the projecting processes of the two palatine bones; they are of a flattened trigonal shape, of varying length, curved from within outwards, and generally having their base towards the mouth beset with teeth.

The Inferior Maxillary or Lower Jaw bone (o.n.*) is made up of two lateral branches joining by ligament in front: each branch consists of two pieces, a hinder articular piece (o.*), the posterior end of which has the articular surface joining it with the tympanal bone, and a front or dental piece (o.), which is filled with teeth; the bone is convex from before to behind, and from above downwards, externally, and concave within; it is deeper behind than before, but deepest about the middle of the articular piece from the elevation of the coronoid process.

The position of the Flat Fish, as the *Plaice* (fig. 9.), upon their left side has a peculiar influence on the form of their head, inducing the disposition of both their eyes upon the right or upper surface, and the curving of their jaws to the left or under. The left orbit (γ.) is situated on the frontal surface of the face; has a complete bony margin, very deep in front. The principal frontal bone (f.) takes its usual course to its termination upon the ethmoid bone, but its left edge († †.) is straight, and has not the slightest indication of posterior or anterior frontal pieces or orbit; its right edge (†.), on the contrary, is hollowed out considerably, forming the supra orbitar edge. The posterior frontal bone (f.*) is much developed, and curving forwards, forms the hind part of the left orbit, of which the fore part is formed by the anterior frontal (f.**) of considerable depth and extent, which makes a large sweep, and curves back to meet the posterior. At the point where the anterior frontal begins to run back, it sends down a little process towards the corner of the mouth, the hind edge of which, together with that part of the bone forming the right or suborbitar edge of the left orbit, forms also the very slight bony edge of the right orbit (δ.), so that the right eye lies embedded in fat upon the right pterygoid bone, as the left rests on the right side of the principal frontal and the palatine portion of the sphenoid. The apertures of the nostrils (ε. ε.) are also on the right side, and both nasal bones supported on the end of the right anterior frontal. As to the jaws, the right palatine and intermaxillary bones are very small, and the latter toothless, as also the right branch of the inferior maxillary. But the left palatine and intermaxillary bones are large, and the extremity of the vomer curving to the left



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when the mouth is opened, and projected instead of stretching forwards, it twists to the left or towards the ground. The left intermaxillary and branch of the inferior maxillary bones are well furnished with teeth.

The Bones forming the Branchial Apparatus will be more conveniently considered with the Respiratory Organs.

3. Of the Extremities.

The analogues of the limbs of other Vertebrate animals are the Pectoral and Ventral Fins of Fishes; the resemblance between the correspondent parts of the former to the anterior limbs, though not very marked, is however perfectly apparent, but that of the latter to the posterior limbs is very slight and indistinct.

The Pectoral Fins are suspended from a collar or girdle surrounding the gullet, interposed between the gills and the belly, in some Cartilaginous Fishes, as the *Sharks*, not attached, and in others, as the *Rays*, attached to the spine, but in the rest of that section of Fishes, and in all those which are Bony, connected with the skull above, and with the sternal bone or cartilage below. This may fairly be called the *shoulder girdle*, as it actually serves the same purpose as the shoulder-bones of Beasts. The Shoulder Girdle in *Sharks* and *Rays* is of very simple structure, consisting of a single piece of cartilage, bent in correspondence with the form of the body of the fish; thus in the *Piked Dog-fish*, the shoulder girdle resembles the letter U (fig. 7. p. p.*); its bottom (p.) crossing the belly may be considered as the clavicular part, and is widened from before backwards, and cupped to lodge the heart, whilst the branches (p.*) of the letter ascend upwards and inwards towards the vertebral column, but are not joined with it, as the scapular part of the girdle. In the *Rays*, on the contrary, as the body is much flattened, so is the shoulder girdle, which is also more largely developed on account of the large size of the fins attached to it. The clavicular part (fig. 6. B. p.*) is of much greater extent from side to side, is narrow at its middle, but considerably lengthened from before backwards at each extremity, whence it bends suddenly upwards and inwards at an acute angle, forming its scapular part (p.) of triangular shape, its base below perforated with several holes, whilst its upper end rises and is sometimes attached to the scapular or expanded transverse process of the spine either by a joint, as in the *Skate*, or consolidated with it so as to make a perfect girdle, as in the *Thornback*, or connected both to the transverse process and body of the spine, as in the *Sting Ray*. The articular processes for the fins upon the girdle are in the *Sharks* little juttings backwards (fig. 7. p.†) of the cartilage, just above the curving base, each terminating in a single or convex surface, upon which is received the cupped end of the fin formed by two flattened cartilages (q. q.), at the other end of which the fin rays are attached. In the *Rays* (fig. 6.) the articular surfaces on the girdle are widely separated from each other by two large holes (φ. φ.*), of which the hinder (φ.*) is subdivided by a narrow strip; the articular surfaces (p.†) themselves are all convex, but the fore and hind are much larger than the middle one, and the latter is ovaloid from before backwards, whilst the former two are ovaloid with their long axis from above downwards. Of the three basal pieces of the fin, which resemble a bow, the middle piece (C. q.) is very thin and flat, forming the bow handle, whilst the arms (r. r.) have each a deep vertical plate at right angles with the flat fin, thus forming a deep cavity, especially on the under surface of the fish, for the lodgment of the great pectoral muscles; each arm consists of several pieces, taper consecutively towards their extremity, the anterior is connected by ligament with the snout, and the hind extremity similarly to the pelvic analogue and tail.



Among the Bony Fishes the *Common Eel* exhibits a very simple Shoulder Girdle, suspended on but not articulated with the spine (fig. 10. p.); it consists of two nearly angular branches joining together at an angle by their fore and lower point, which is attached to the hinder sternal bone; thence ascending outwards and upwards bounds the gill aperture, forming the part upon which the gill-flap strikes, and has upon the fore and outer part of its upper extremity a little bone (p. *), corresponding to Cuvier's scapula, whilst from the back of the large bone stretch two thin flat cartilages (q. q.) forming the basal parts of the fin, and upon the extremities of these are attached the rays.

In most Bony Fishes the Shoulder Girdle is connected to the skull, each lateral piece consisting of an upper and lower portion. The upper (fig. 15. p.*) may be considered, as stated by Bakker, to be analogous to the blade bone or scapula; its upper extremity has sometimes two, as in the *Perch* (fig. 11. A. p. t. 2.) and *Plaice*, sometimes three processes, as in the *Haddock* (fig. 17. p. 1. 2. 3.), which project forwards and inwards to be attached to the skull; from the root whence these spring, another process (p. 4.), sometimes indeed as a distinct bone, descends, and, overlapping the subjacent portion, is considered by Bakker as analogous to the acromion scapulæ, which designation he therefore applies to it; Cuvier, however, calls this the scapular, and the former the suprascapular bone. The lower most considerable portion of the girdle (q. r.) specially forms the hind boundary of the gill-opening; its general shape, though subject to variety, is that of a scimitar, increasing in breadth towards its tip and having its edge inclined outwards. It has been considered by Geoffroy St. Hilaire to correspond to the clavicle; Cuvier, in his *Leçons d'Anatomie Comparée*, spoke of it as the coracoid bone, but in the Osteology to his *Histoire Naturelle des Poissons* he says, "it must necessarily correspond to the humerus." Bakker's view, however, if it be absolutely necessary to hunt up analogies, seems more correct than either: he considers this portion a compound of the clavicle and humerus, and names it the *Cœnosteon* or common bone, the upper and outer part (q.) being the humerus, and the fore part (r.) the clavicle, the inner edge of which is often inclined inwards, so that a kind of pit is formed for the lodgment of some of the fin muscles. Extending backwards and downwards from the inside of the top of the cœnosteon into the muscular walls of the belly is a long, slender, and pointed bone, sometimes consisting of one piece, as in the *Haddock* (s.), sometimes of two, three, or more consecutive pieces, as in the *Perch* (fig. 11. A. s. s.*) and *Salmon*. This was formerly considered analogous to the furcula in Birds, but it is now more commonly held as corresponding to the coracoid process of the blade-bone, and is therefore called the Coracoid bone. Dumeril has, however, recently stated that, instead of belonging to the shoulder, it is part of the pelvis. In the hollow at the back of the cœnosteon is attached the bony plate (t. t.*) held to correspond with the fore-arm, upon which the hand, consisting of carpus and fin rays, is fixed. This plate sometimes descends vertically through the pit, composed of two pieces, the upper of a squarish shape, the radius or

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spoke-bone (t.), the lower somewhat scimitar-shaped, connected above with the spoke-bone, more or less in front with the cœnosteon, and by its tip below with the clavicular part of that bone is the cubit or ulna (t.*). There is usually an aperture (γ.) between the lower edge of the spoke-bone and the upper edge of the ulna or cubit, a notch for this purpose existing on each; a second and considerably larger aperture (δ.) often exists between the front of the cubit and the back of the clavicle, the edge of the former being so carved out that its tip merely joins with the latter bone; this is well seen in the *Haddock* (fig. 15.*). In the *Opah* and *Brama* the cubits are of enormous extent, and both protect the alimentary canal and support the expanded walls of the belly. The vertical position of the arm-plate exists in the *Jugular* or *Subbrachian Fishes*, in which the ventral are placed just below the pectoral fins upon the so-called throat of the fish, the latter fins having then a more elevated position. In the *Abdominal Fishes*, of which the ventral are far behind and unconnected with the pectoral fins, the arm-plate, instead of being vertical, is rather horizontal, joining the back of the cœnosteon at right angles: sometimes it consists only of two pieces, as in the *Pike*, but at others, as in the *Salmon*, *Carp*, *&c.*, a third piece is added, which passing upwards and forwards from the junction of the cubit and spoke-bone, rests on the back of the clavicle like a lean-to roof. Upon the free ends of the spoke-bone and cubit are placed some little bones (u.), varying in number from two to five, but mostly only four, which are the analogue of the carpus; sometimes these are flattened and like irregular discs, as in the *Gurnard*, but not unfrequently they assume a lengthy form, and have the general appearance of metacarpal bones, as in the *Salmon*. The greater number of these bones are articulated with the cubit, whilst on the spoke-bone there is but one; this latter bone exhibits however the remarkable circumstance of supporting the first ray of the fin, not unfrequently movable, independent of the fin, whilst the other rays are supported by the carpal bones. The *Angler* has its two carpal bones (fig. 18. u. u.) enormously developed, and of so great resemblance to the human radius and ulna, that they have been described as those bones. The *Gurnard* is remarkable for the size and flatness of the carpal bones, of which the lower two have distinct articular surfaces for the attachment of the lower three fin rays, which, distinct and detached from the fin, depend like so many fingers, and serve the purpose of feelers. The fin rays, considered analogous to the fingers, are sometimes each single bony threads of various lengths; sometimes each thread consists of numerous short but tapering cylinders joined end to end, and sometimes, beginning as a simple thread, they divide subsequently into two, which run parallel and close adjoining to the margin of the fin.

The Ventral fins are analogous to the hinder extremities of other Vertebrate animals, but consist of fewer pieces. In the *Rays* and *Sharks* only is there any thing like a distinct pelvis, which is simply a cartilaginous band (figs. 6.* 7. v.) crossing the hind part of the belly in front of the vent, and having its extremities slightly curved upwards, to be connected by ligament in the *Rays* with the hind part of the great pectoral fins, whilst in the *Sharks* it is merely supported in the muscular walls of the belly. From the hinder edge of this band, and at a little distance apart, a pair of straight or slightly curved pieces (v.*) of cartilage stretch back, upon the outer edges of which the fin rays are attached. In the *Sturgeons* the pelvis has not this band-like form, but resembles that of the Abdominal Fishes. The pelvic bones in Bony Fishes are of different shape: if, as in the *Subbrachial* or *Jugular* Fishes, the ventral fins are placed beneath the throat and behind and below the pectoral fins, the pelvic bones are a pair of isosceles triangles, of which the longest sides join, and the shortest, which are the posterior, support the fin rays, as in the *Perch* (fig. 11. v.), whilst their wedge-shaped anterior extremity is received within the angle of the shoulder girdle. Sometimes, as in the *Dory*, these bones, instead of being flat horizontally, are flat vertically, and closely approximated (fig. 17. v.); indeed, in some Fishes, they become consolidated into a single piece, having a double articular surface for the fin rays. If, on the contrary, the ventral fins are set far back, as in the abdominal fishes, of which the *Salmon* is a good example, each fin is supported on the base of a triangular bone (fig. 16. v.) suspended in the muscular walls of the belly, of which the apex is in front: these bones are sometimes united at their apex, as in the *Pike*, sometimes by a little bone intervening between their bases, as in the *Salmon* (v.*), and at other times each piece consists of two arms united at an angle, of which the longer (v.) stretches forwards and the shorter (v.*) runs inwards to join its fellow, as in the *Angler* (fig. 18.*).

### Of the Skeleton of Reptiles.

The Skeletons of Reptiles exhibit so many peculiarities in their several Orders that at first sight they might be presumed to belong rather to distinct Classes. In most the spinal pieces are movable, but in some their greater number, although distinct, are, from peculiar causes, immovable; all, however, excepting one Order, have the form and connection of the vertebral bodies alike. The ribs are either distinct, in great number and unattached, except to the spine, or connected with a breast-bone of great width, and joined also with each other to form a large shield. The apparatus of the jaws either resembles that of Fishes, excepting that the greater number of their pieces are actually separable from each other under peculiar circumstances; or they are, with the exception of the movable lower jaw, immovably connected with each other and with the skull. Some are entirely destitute of limbs, some have only hind, and others only fore limbs.

1. Of the Spine.

The most remarkable form of Spine in Reptiles is that of the *Amphibious* Order, comprising the *Siren*, *Amphiuma*, *Proteus* (fig. 8. A. a. h.), *Axolotl*, and *Menobranch*, in which the vertebral bodies are hollowed conically before and behind as in Fishes; but in most other Reptiles, one extremity is semiglobular and the other concave, so that between the adjoining bodies of each two vertebers a perfect ball and socket-joint is formed with the concavity (fig. 2. A. n.) in front, and the convexity (b.) behind, as well seen in the *Python*. In the *Tailed Batrachians*, however, as the *Warty Eft*, the concavity (fig. 9. C. b.) is behind, and the convexity (a.) in front. The vertebral bodies are mostly cylindrical, contracted in the middle, more or less compressed or depressed according to their position in the Spine, and of varying length in the different Orders, thus shortest in the *Saurous* and *Ophidian*, longest in the *Chelonian*, and in the latter also widest. The



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arches of the vertebers which support the processes remain distinct pieces throughout life, though closely connected by alternate delicate toothings to the bodies. The size of the spinous processes varies much; in the *Amphibious* and *Batrachian* Orders they are low, forming merely a slight ridge; in the *Saurous* and *Ophidian*, especially in the latter, they are deep and extensive (figs. 2. 3. s.); in the *Chelonian*, they are not only large and deep, but their tops expand into large horizontal angular bony plates (fig. 6. A. a.), like the heads of large buttons. Inferior spinous processes also exist, as in Fishes (fig. 7. A. a*.), on the bodies of all the tail vertebers of greater or less length according to the depth of the tail, not immovable, but articulated one to each body; in the *Serpent* Order, indeed, they exist on almost all the vertebral bodies, and in some, as the *Rattlesnakes*, upon the tail they are double. In the genus *Hydrophis*, both the upper and under spines of the tail vertebers are double as long as those of any other. The articular processes are generally horizontal, the hinder part of one verteber overlapping the anterior pair of the following. In the *Serpents*, however, each is cleft or forked, the one fork being received into the other, so that the connection of the spinal pieces is materially strengthened. The transverse processes vary in size considerably; those which support ribs have articular surfaces upon their extremities of corresponding size. In Reptiles with distinct necks, as the *Lizards* and *Turtles*, the transverse processes are most largely developed in that region, especially in the *Crocodiles*, where they form distinct pieces, simulating ribs by the long processes (fig. 7. A. 1. 2. e.) which they send backwards, overlapping each other along the sides of the cervical Spine.

Some vertebers have peculiar characters. In the *Amphibious* and *Batrachian* Orders, of which the *Proteus* and the *Frog* may be taken as examples, the first verteber which connects the Spine to the skull has a broader body than the other vertebers. Meckel describes in the *Proteus* a narrow anterior process received into the gap left by the absence of the basilar part of the occipital bone; in the *Frog*, instead of this process, is a slight cleft (fig. 1. A. 1. a.), which separates the wide articular sockets for the occipital condyles. The *Pipa* is distinguished by the large transverse processes of this verteber (fig. 10. A. 1. c. c.), which other Frogs have not. In the *Turtles*, the first verteber (fig. 6. B. 1.) consists of three pieces, a square middle portion or body (a.) having one concavity in front for the occipital condyle, and another behind for the rudimental verteber, and a pair of lateral pieces (b. b.) which converge above, and uniting by ligament, form the vertebral arch; the front (b*) of each has at its lower part a concave articular surface for the condyle of the occipital bone, which is thus received on three cavities; their hinder extremity is lengthened into two processes (b.**), the lower shorter one, with an internal articular surface, overlaps the side of the rudimental second verteber; the upper longer one stretches backward, with an articular surface on its inner side corresponding to one on the third verteber. The second or rudimental verteber (2.) consists simply of a body resembling a very thick cup, of which the convexity in front is received in a socket formed by the junction of the three pieces of the first, and the concavity behind upon the convex head of the third verteber (3.). In the *Crocodiles* the first verteber (fig. 7. A. 1.) consists of four pieces, the body (a.), two lateral pieces (b. b.), and a superior interposed fourth piece (c.), which forms the vault of the vertebral arch and little spine. The second or rudimental verteber (2.) is united with the front of the next verteber (3.), thus presenting the tooth-like process or pivot always borne by the second verteber of higher animals. In the *Snakes*, the first verteber (fig. 29. A.) is a single ring, through the lower part of which (a. *) the pivot on the front end of the second verteber (B. b.*) passes to the articular surface on the skull.



In the *Tailless Batrachians* the ninth verteber, sometimes called the sacral bone, has large transverse processes for the attachment of the pelvic bones; these in the *Frogs* (fig. 1. 9. e.*) are slender and flattened, or long and triangular with the base outwards; in the *Toads* they are more bulky, but in the *Brown Toad* and *Pipa* (fig. 10. 9. e.*), instead of transverse length, are longest from behind forwards, and more hatchet-shaped. The tenth verteber or coccygeal bone (fig. 1. 10.) is long, slender, and like a flattened three-sided poniard, its broad base in front and its free hinder extremity tapering, and reaching nearly to the end of the trunk. That this is really a verteber, against which its appearance much militates, is proved by rudimentary transverse processes and apertures for the nerves existing in the *Edible Frog*, and the latter both in *Toads* and *Frogs*.

In other Reptiles the tail vertebers gradually taper, losing first their transverse and subsequently their spinous processes, but in the *Rattlesnakes* the last piece is massive and compressed (fig. 3. r.), for the purpose of supporting the horny rattle fixed upon it.

2. Of the Head.

The Head of Reptiles is distinguished from that of Fishes, by its fewer pieces and more flattened form, by the jaws not being projectile, and by its articulation with the spine being effected, except in one Order, by a convex instead of a concave articular surface. The different Orders of Reptiles exhibit various forms of Head, at first seeming rather to belong to distinct classes; but closer examination shows they form but one, the configuration of the bones varying only in such degree and after such model as the peculiar habits of the Order require, the same bones actually existing in almost all.

In the *Amphibious* Order, the Occipital bone of the *Siren* (fig. 11. A. B.) and *Proteus* (fig. 8. B.) forms but the very smallest portion of the base of the Skull, and consists almost entirely of two articular pieces (f. f.), each having a joint surface ($\phi$.) for the first verteber, connected together, and forming the lower margin of the occipital hole ($\gamma$.), which is perfected on the sides and above by the union of a pair of converging pieces.

The Sphenoid bone is the largest bone of the Head, forms the entire base of the Skull, and in the *Siren* (g.) the whole palate, also reaching the intermaxillary bones, and probably absorbing the Vomer, which does not exist here as a distinct bone. In the *Proteus*, however, it (g.) extends less far forwards, and its pointed anterior extremity runs between a pair of bony plates studded with delicate sharp-pointed teeth (h. h.), which seem to be the Palate bones, and not, as Cuvier supposes, a divided vomer, each piece being connected behind by a little bony stret, (which is certainly the pterygoid piece of the sphenoid,) with the tympanal portion of the temporal bone in the *Proteus*, but which is deficient in the *Siren*, and therefore these palate bones

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(h. h.) underlap in that animal the palatine part of the sphenoid.

The sides of the Skull are formed immediately in front of the occipital by the petrous pieces (B. k.) of the Temporal bones, in which are the large oval holes perfected behind by the occipital. The Parietal bones received behind in the space between the occipital and petrous are in the *Siren* very large (o. o), and, continuing far forwards, diverge and receive between them the frontal bones; in the *Proteus*, however, they are less long, and more square in front.

The Frontal bones (fig. 11. A. p. p.), a pair, form the vaults of the very imperfect orbits; beneath their hinder extremities, and also under the front edges of the parietal, are a pair of bones, one on each side, the orbitar piece of the sphenoid (g.**) of Cuvier, in part performing the functions of the ethmoid bone.

The Nasal bones (q. q.), thin and narrow, are received in clefts of the frontal bones, and on their outer edges are the long posterior branches of the Intermaxillary bones, of which the front (r. r.) stretch out laterally and have delicate curved teeth on their lower edge. The only trace of Upper Jaw bones are in the *Siren*, a pair of little pieces (s.) at the outer corner of the intermaxillaries, and suspended on the lip; in the *Proteus* they are wanting.

The suspensory apparatus of the Lower Jaw to the Skull in the *Amphibians* closely resembles that of the *Sturgeons*. The Tympanal bone is somewhat cylindrical, and narrows in the middle in the *Proteus* (C. m.); its upper extremity is received into a cavity in front of the petrous bone, and the lower, which suspends the lower jaw, has attached to its inner side the pterygoid piece of the sphenoid bone; in the *Siren*, however, the upper end of the Tympanal bone (C. m.) is sharp and thin, and not in a cavity, but rests upon the upper edge of the petrous bone; its lower end, thick and hollowed, receives the condyle of the lower jaw.

The Lower Jaw consists of two branches joined in front, and each of four pieces; the bottom or base is formed of two; in the *Proteus* the anterior (C. v. 1.) supports teeth, but in the *Siren* (C. v. 1.) it is deeper, and has a sharp horn-covered edge: the posterior (2.) forms the angle of the jaw, above which is the articular piece (3.), forming a semiglobular condyle in the *Siren*, but a cavity in the *Proteus*; between it and the dental piece a little thin connecting plate (4.). From the angles of the lower jaw in the *Siren* descend the converging lateral branches of the Tongue bone which are connected with the branchial apparatus, and will be hereafter described.

The remaining *Amphibians*, viz., the *Menobranch*, *Axolotl* and *Menopome*, with the exception of the branchial apparatus external in the former, as in the *Siren* and *Proteus*, but concealed in the latter, as in the *Amphiume*, have their Head much resembling that of the Order to be next considered.

The *Batrachian* Order includes those Reptiles with flattened Heads and great width of jaws; of which some have tails and others are tailless, whence they are divided into two Families.

The *Tailed Batrachians*, as the *Salamanders* (fig. 12.) and *Efts* (fig. 9.), have the Occipital bone consisting of two pieces (A. B. f. f.), each with a condyle for the first verteber; above it joins a pair of Parietal bones (o. o.), in front of which are a pair of Frontal bones (p. p.), bounding the orbits above, and each having on its outer and fore edge a separate or anterior frontal piece (p.*), to form the orbit in front. Before the frontal pieces rise up the little ascending branches of the Intermaxillary bones (r.), a pair; their horizontal branches form the front of the upper jaw, the sides of which are perfected by the horizontal branches of the Superior Maxillary or Upper Jaw bones (s.), which curve outwards and backwards, but do not reach the tympanal bone; their ascending branch rises in front to the anterior frontal piece, and is separated from the ascending Intermaxillary branch by the little squarish Nasal bone (one on each side) (q.): between which latter is on each side the aperture of the Nostrils. The Sphenoid bone still forms the principal under part of the skull; in the *Salamanders* (fig. 12. g.) it stretches back into the occipital hole, between the Occipital bones, and this very remarkably in the *Menopome*; in the *Efts* (fig. 9. g.), however, it does not participate in forming that hole. Its Pterygoid pieces (g.†) are, in the *Salamander* and *Eft*, somewhat triangular, with the base behind, and the angles truncated; the inner one is separated from the body of the sphenoid by the petrous bone (k.), the outer joins the articular piece of the tympanal (m.); its anterior sharp angle projects forward in the direction of the upper jaw, but unconnected with it, the malar bone being deficient; in the *Menopome* this process is very large and square, filling up nearly the whole space between the tympanal bones and the maxillaries. In the *Salamanders* the sphenoid has its orbital plates (g.**), which bound the insides of the orbits, and are connected with the parietal and frontal bones, attached along the edges of the greater part of its wide palatine portion (g.*), the angular extremity of which separates the hatchet-shaped Palatine bones (h.) connected by their long outer edge with the intermaxillaries and maxillaries, but diverging in front from each other and forming a large incisive hole (ĉ.). In the *Efts* the palatine process (g.*) of the sphenoid is long and tapering, and separates only the long posterior processes of the Palatines (h.*) which are interposed between the palatine and orbital processes of the sphenoid. The inner margins of the palatines unite together and have only a very slight aperture between them. In the *Menopome* they are attached only in front of the sphenoid, without any intervening aperture. The Petrous bones (k.), one on each side before the occipital, have the parietal above and the sphenoid below; and from the upper margin of each passes outwards and downwards the Tympanal (m.) consisting of an upper piece, the sole representative of the squamous portion of the Temporal, and a lower, which, first lapping on its inside, descends, becomes free, expands and forms the articular piece for the lower jaw, against the inside of which the pterygoid piece of the sphenoid juts. The Lower Jaw (C. v.) consists of two branches, each composed of an articular (2.) and a tooth-bearing piece (1.).

The Head of the *Tailless Batrachians*, viz. *Frogs* and *Toads*, differs in a few particulars from that of the *Tailed* Family. In the *Common Frog* the Parietal and Frontal bones are united, so that but one pair (fig. 1. p.) forms the vault of the Skull, and hence Dugès has very properly named them Parieto-frontal; these, at the upper margin of the orbit, have a little depending edge which assists in bounding the cavity of the Skull. In front are the Fronto-nasal (q. q.), a pair of triangular bones with their outer angles descending to form the front of the orbits; Dugès considers them as the

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anterior frontal and nasal bones conjoined, but Cuvier says they are anterior frontal pieces, and that the Nasal bones are little rudiments contained in the cartilage of the nostrils. The Mastoid and Petrous pieces (k.) of the Temporal bone confounded together project laterally in front of the occipital, and from the upper edge of the petrous piece descends the tympanal. The upper part of the Tympanal is the analogue of the scaly parts in higher animals, and is horizontal (m. 1.); from it passes downwards and backwards a process (2.) which partially supports the drum membrane of the ear, and at its tip stretches forward another horizontal process (3.), thick behind, to form the condyle for the lower jaw, and thin before to join the jugo-maxillary bone, and so connect itself with the upper jaw. The body of the Sphenoid (fig. 1. B. g.) is cruciform, its shaft or palatine process projecting forwards as far nearly as the parieto-frontal above, and its arms laterally beneath the petrous bones. Its Pterygoid pieces (g.†) are compared by Dugès, in shape to the Greek λ, the inner shorter leg resting against both the transverse branch of the cruciform body (g.) and the petrous bone; the outer running back against the articular piece of the tympanal bone and the long, thick, anterior limb continued forward along the inside of the jugo-maxillary, to the palate bone. In front of the anterior extremity of the sphenoid, and beneath the ends of the parieto-frontal bones, is a little, flattened, circular, bony canal, divided by a partition (x.), through which the olfactory nerves pass to the nose, proving it is the Ethmoid, as Dugès considers, although Cuvier doubts it. On each side of this a little transverse piece, the Palatine bone, runs outwards to join the anterior process of the pterygoid; and between these and the intermaxillaries a pair of little bony plates, in the *Frog* beset with teeth, are the Vomers (i.). The Head of the *Bombinator Fuscus*, described and figured by Dugès, is very remarkable for its resemblance to that of the Sea Tortoise, being entirely covered with a bony casque except in the intermaxillary region.

The Head of the *Ceciliæ* has, like the *Salamanders*, a large Sphenoid bone (fig. 13. g.), forming the entire base of the Skull, stretching posteriorly between the articular pieces of the Occipital bone (f. f.) to form the lower edge of the occipital hole, and joining anteriorly with the under surface of the Intermaxillo-nasal or conjoined intermaxillary and nasal bones (r.): on the sides of the sphenoidal body are the pterygoid pieces (g.†), between which and the intermaxillo-nasal are the Palatines (h.); and to their outer edges join the jugo-maxillary (n.), or conjoined jugal and maxillary bones, which rise upwards as expanded plates to join edges of the parietal (o.), frontal (p.), and intermaxillo-nasal (r.); thus the whole upper surface of the Skull and face consists of a perfect bony surface without any indication of orbit except the small aperture (v.) in each jugo-maxillary; and on the under surface only between the arches of the cheeks and the palatine and sphenoid is it seen that any cavities intervene between the Skull and the bony arch just mentioned.

The remaining Orders of Reptiles, viz. the *Ophidian*, *Saurous*, and *Chelonian*, are distinguished by having only a single condyle or articular surface on the Skull for its junction with the spine, and by the increased development of the bony apparatus of their auditory, visual, and olfactory organs, by means of which the perfection and strengthening of their jaws is materially increased. The size of the Skull or brain-case is still small, for its seeming increased bulk in the *Lizard* and *Crocodile* Orders, and in some of the *Tortoise* Order, depends on the addition of processes to some of the bones of the Skull, on the great development of others, and the appearance of new bones, all of which have relation to the jaws and not to the Skull itself.

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The *Ophidian* Order is divided primarily by Müller into two Families, in reference to the size of the mouth; 1st, the *Macrostomatous*, *Large mouthed* or *True Snakes*, in which not only is the gape wide, but the several pieces of the face and jaws are separable from each other, so as to enable the Snake to gorge animals of considerably larger size than its own: 2nd, the *Microstomatous*, *Small mouthed*, *Serpents* or *False Snakes*, in which the gape is small, and the lower jaw alone movable: amongst these are seen the transitional characters which lead to the Order of *Lizards*. The greater number of both Families are devoid of limbs, and move simply by the aid of their ribs; but in a few, rudiments of those organs more or less fully developed exist.

The True Snakes are divisible into three tribes, 1. The *Unpoisonous*. 2. The *Fang-less Poisonous*, and 3. The *Fanged Poisonous* Snakes: of the first, in which the upper jaw-bone is large, long, and furnished with a row of strong curved teeth; and of the third, in which that bone is short, thick, and armed with one or two very large curved hollowed teeth, the *Common Green Snake* and the *Viper* present good examples in this country, and indicate the well marked characters of the two tribes. The *Fang-less Poisonous* Snakes have, however, a close resemblance in the construction of their jaws with those of the *Unpoisonous*, and it is only by examination of their teeth that their poisonous character can be detected: thus in the genus *Dipsas*, the upper jaw-bone, of nearly similar proportions to those of *Unpoisonous* Snakes, has a row of teeth, the last and longest of which is much curved and grooved on its inner side as a poison canal, whilst in the *Bungari*, the same bone supports a short poison tooth, and two or three solid ones behind it, and in the *Spectacle* Snake but a single poison tooth, only twice the length of the palate teeth.

The Occipital bone (fig. 2 and 3. C. and D. f.) consists only of two pieces: the lower has at its hinder part a hemispherical articular surface or condyle (φ.), for the first verteber; its front edge is connected in the middle with the body of the sphenoid, and on each side with the petrous bones, and its upper edges with its own upper piece (D. f.) of which the front is united with the parietal bone. The body of the Sphenoid bone (C. g.) completes the bottom of the Skull, and by its palatine process (g.*) joins the vomer in front; both body and process are longer in the *Unpoisonous* than in the *Poisonous fanged* Snakes; upon each side of the body juts out a little flat articular process (ρ.), upon which the pterygoid bones rest. The greater part of the vault of the Skull is formed by the single Parietal bone (D. o.), which in the *Unpoisonous* Snakes has its posterior half narrow, and provided with a middle longitudinal ridge, and its fore part much expanded laterally; on the contrary, in the *Poisonous* Snakes, the whole is short and wide, without any ridge, but its lateral edges are scooped out in a semicircular form: in front it joins with the frontal bone, and by its lower edges with the sphenoid. The Frontal bone (p.) is usually described as consisting of four pairs of pieces,

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all of which in the *Unpoisonous* Snakes are largely developed: 1. The *true* or *middle* frontal (p. 1.), connected together by their inner edges, occupy the middle of the front parietal edge; in the *Unpoisonous* Snakes they are wide laterally, in the *Poisonous* more square. 2. The *posterior* frontal (2.), which pass down from the adjoining corners of the former and of the parietal, to form the hinder boundary of the orbit; in the *Poisonous* Snakes they are small. 3. The *anterior* frontal (3.) are of an elongated triangular shape with their bases resting against the front of the middle pair, separated from each other by the nasal bones, but stretching out, and curving downwards to form the front of the orbit; in the *Poisonous* Snakes these pieces are very small. 4. The *supra-orbitar* or *orbito-frontal* (4.) are, a little piece at the upper edge of each orbit received in a notch formed by the first three pieces, but do not exist in the *Poisonous* Snakes. Between the anterior frontal pieces, and nearly filling the intervening space, are situated the Nasal bones (q.), joined by their inner edges, and beneath with the Turbinated, which stretch forwards from between the junction of the nasal and anterior frontal bones. Another pair of bones, the Petrous (k.), complete the Skull, placed one upon each side between the occipital and parietal above, and the sphenoid bone below; these contain the internal organ of hearing, and have large apertures for the passage of the trigeminal nerves. Extending forwards from the sphenoid, the Vomer (C. i.) runs on towards the muzzle between the palatine bones (h.), and on each side of its fore part are the turbinated bones. On each side of the sphenoid bone and vomer, passes a slightly waving bony plate, supporting teeth, and consisting of two pieces united together by their overlapping extremities, a little behind the junction of the sphenoid and vomer; the posterior of these two pieces is the pterygoid, and the anterior the palatine bone; the latter has teeth throughout its whole length, but the former is only partially toothed. The Pterygoid bone (C. g. †) is somewhat trigonal, with its base downwards, and its sides hollowed; widest at its middle, where it rests internally upon the articular process of the sphenoid bone, and having externally a projecting flat articular surface for the transverse or stret bone; behind which the bone flattens laterally, curves outwards, is applied to the inside of the tympanal bone, but its extremity stretches beyond. The Palatine bone (C. b.) overlaps the former by its hinder extremity, and is applied to the under part of the parietal; it sends a lip inwards (h.*) to the palatine process of the sphenoid, and on the outer side is connected with the upper jaw bone; its anterior extremity reaches to the turbinated bone. From the rough articular surface on the outer edge of the middle of the pterygoid bone, passes forwards and outwards the Transverse or *Stret* bone (C. o.); this, in the *Unpoisonous* Snakes, is short and stout, and, continuing for some distance on the inside of the hinder extremity of the upper jaw-bone, prevents its too close attraction to the pterygoid, but in the *Fanged Poisonous* Snakes it is long, slender, slightly arched, and continuing forward, terminates opposite to the palate bone, in an articular surface upon which the upper jaw-bone moves. May it not really be the Jugal or Malar bone? The Upper Jaw-bone (C. D. s.) differs remarkably in the two groups of Snakes under consideration. In the *Unpoisonous* Snakes it is of large size, reaching from the stret bone to the front of the muzzle, that is, about three-fifths of the total length of the Head; it curves forward, widens below the orbit of which it forms the inferior margin, is widest beneath the hinder edge of the anterior frontal bone, and thence gradually tapers to terminate at the side of the intermaxillary bone; its upper surface is convex from above downwards, and its under surface towards the mouth concave, but the outer under edge is wide, and supports a single row of teeth throughout its whole length. In the *Fanged Poisonous* Snakes the Upper Jaw-bone (fig. 3. D. s.) is short and thick, forming a stout base, in which the fang teeth, two or three, are implanted, and has an articular surface by which it moves like a hinge upon the extremity of the stret and palate bones. The Intermaxillary (C. D. r.) bone is single and T-shaped, its arms interposed between the fore extremities of the upper jaw-bones, but only connected with them by ligament, and its stem, running horizontally backwards between the nasal bones, is attached to the tip of the vomer; in the *Unpoisonous* Snakes it has teeth, but in the *Poisonous* it is toothless. The Mastoid bone (C. D. j.) is nearly horizontal, and paddle-shaped, its blade applied against the side of the parietal and occipital above the petrous bone, and its thicker and flattened rounded handle stretched outwards and backwards, receiving upon its outer under extremity the Tympanal bone (fig. 2 and 3. m.), which is short and vertical in the *Unpoisonous*, but long, slender, and stretching outwards, backwards, and downwards in the *Poisonous* Snakes; it is somewhat cylindrical, with more or less distinctly marked ridges; its upper end large and rounded where joining with the mastoid, and broad and irregular at the lower end for its articulation with the lower jaw.

The Lower Jaw (fig. 2. and 3. D. v.) consists of a pair of branches separable from each other at the chin, and each branch consists of two pieces, united, as in Fishes, by slipping the one into the other: the hind or articular piece (1.) has the socket for the tympanal bone, and in the *Unpoisonous* Snakes is of considerable depth and bulk, but shorter than the second piece (2.); in the *Poisonous*, however, it is slender and of very considerable length, so as to form the greater part of the lower jaw, which, on the contrary, is, in the *Unpoisonous* Snakes, composed of the fore or dental piece, supporting very strong curved teeth; the dental piece in the *Poisonous* Snakes is short, and its teeth few.

The False Snakes or Serpents are connected to the True Snakes by the genus *Tortrix* (fig. 14.), in which, although their Skull is completely bony, the front of the orbits bounded by anterior frontal bones, the pterygoid palate, intermaxillary, and both superior and inferior maxillary bones furnished with teeth, yet is not any of the jaw apparatus separable, nor even the branches of the lower jaw, although loosely connected; the mastoid bones (j.) are merely rudimental and immovable; the small tympanal bones (m.) are attached directly to the Skull itself; and the single occipital condyle (φ.) has on it a pair of little knobs. The genus *Typhlops* (fig. 15.) is remarkable for the narrowness of its forehead and expansion of its face, somewhat like a flattened bladder: the former depending on the contraction of the Frontal bone (B. p.), which descends on each side to join the edges of the palatine process of the Sphenoid (A. g. *), and form the shallow orbital cavities, which are slightly indicated behind by the projecting corners of the single Parietal bone (B. n.), which, crossing the Skull like an arch, de-

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Zoology. scends to the edges of the basal part of the sphenoid. The expansion of the face is produced by the lateral swelling out of the Superior Maxillaries (A. B. s. s.), separated beneath and before by the Intermaxillary (r.), (behind which is the large posterior nasal opening,) and above by the nasal bones. The Occipital (A. B. f.) bone completes the base of the skull, has a single condyle ($\phi$.), alone forms the occipital hole, and above that aperture is vertically divided; its sides are connected with the Petrous bones (k.), but no distinct Mastoids exist. The Pterygoid bones (A. B. g. †), a pair of thread-like crutches, are continued horizontally from behind the junction of the petrous and occipital forward beneath the sphenoid to its very tip, towards which the inner branch of each crutch runs but is not attached, and upon the tip of the outer branch is suspended the reversed L-shaped superior Maxillary bone (s.), the base of which has two teeth. The Tympanal (B. m.) is a short horizontal piece connected with the petrous, but not with the pterygoid; it has a little slender surface for the articulation of the Lower Jaw (v.). The latter consists of a pair of branches united in front, and each near their point furnished with a flattened triangular vertical process (v.*), which ascends into the orbit close to the superior maxillary bone, and is held by Müller to be the coronoid process. The Head of *Rhinophis*, which Müller says is the smallest he has ever seen, is remarkably distinguished from *Typhlops* by its sharp muzzle, depending on the great length of the Nasal bones, and the projection of the Intermaxillary; by the great length of the condyle, whilst the rest of the basilar portion of the Occipital consists merely of a pair of slender branches, including the broad hinder end of the basilar Sphenoidal which forms the entire floor of the Skull, narrowing as it runs forwards between the Palate bones; its pterygoid pieces connected behind with the little Tympanal run close to its edges, join in front with the palate bones within, and with the transverse without, which stretch out to meet the lengthened hinder ends of the Upper Jaw bones. No rudiment even of mastoid bone exists, and the tympanal lies horizontally as in *Typhlops*. The Lower Jaw consists of a pair of divided and slender branches, but the coronoid processes are small and far back. Both jaws have teeth, but not the palate or pterygoid bones. The *Amphisbænæ* (fig. 16.) resemble *Typhlops* and *Rhinophis* in the immobility of the bones of the face, and in the absence of the mastoid and posterior frontal bones, but in many particulars are connected with the Order of *Lizards*, the most remarkable of which is the large size of the Lower Jaw and the cleft ($\xi$) between the parietal and sphenoid bones, depending on the narrowness of the basilar part of the latter, and extending from the petrous bone behind to the large anterior frontal before; the Pterygoid and Transverse bones are very wide in accordance with the large size of the Superior Maxillary bone; and both maxillaries only are toothed. The genus *Chirotes*, commonly placed among the *Skinks*, has its Skull so closely resembling that of the *Amphisbænæ*, that Müller places it with them; nor is its possession of anterior extremities any bar to this arrangement, for, as will presently be seen, other Reptiles are included among the *Skinks* in which no external limbs are visible.*

The *Saurous* or *Lizard-like* Reptiles are distinguished from the *Serpents* by the large gaps on the sides of the Skull, the parietal being simply supported upon the petrous bones by a pair of slender columns in front, and so loosely connected with the occipital behind as to move vertically upon it: the orbitar margins are generally perfected by a malar bone, and a distinct lachrymal bone is commonly found. The bones forming the upper jaw and palate are incapable of any separation, such as occurs in *Serpents*, and the lower jaw, united in front, is also inseparable. The tympanal piece of the temporal bone presents a hollow for the drum of the ear, gradually increasing in size, and its junction with the Skull is effected by the addition of another bony piece besides the mastoid, both of which are attached to a peculiar elongation of the parietal bone. Zoology.

The Family of *Slow-worms*, till recently included in the *Ophidian* Order on account of their snake-like form and want of limbs, connect the *Saurians* and *Ophidians* by means of the genus *Acontias* (fig. 17.), in which the lateral gap (B. $\zeta$.) between the Parietal and Frontal above and the Sphenoid below, is unsupported by any bony column; the posterior under margin of the orbit is imperfect, the Malar bone, as in the Serpents, being deficient; and their Tympanal bone suspended only to the Mastoid, which is attached to a little ridge on the hind and lateral part of the Parietal.

In our *Common Slow-worm* (fig. 18.), *Anguis fragilis*, the Occipital bone consists of four pieces, all contributing to form the vertebral hole, and the basilar provided with a single articular condyle ($\psi$.) for the spine. The basilar Sphenoid bone, like a St. Andrew's cross, stretches one pair (g. 1.) of its arms beneath the lateral occipital pieces, and the other (g. 2.) forwards to support the Pterygoid pieces, between which the bone is truncated, and its azygos process replaced by a cartilage: the front of each Pterygoid piece (g. †) is connected by its outer fork with the Transverse and Malar bone, and by its inner with the Palatine bone. The single Parietal bone (o.), joining behind with the superior occipital, sends out a pair of lengthened processes for the suspensory apparatus of the lower jaw; but not curving downwards on the sides, the large space between it and the sphenoid bone is simply filled with membrane, supported opposite the anterior boundary of the Skull on each side by a delicate bony pillar interposed between the parietal and the spheno-pterygoid piece, which Cuvier calls the *Columella* ($\mu$.); it is probably the analogue of the temporal angle, or of the temporal portion of the Parietal bone. The Frontal bone (p.) has its principal pair of pieces in front of the parietal, and the posterior and anterior, forming the corresponding corners of the orbits; the triangular posterior piece has from its hinder edge a little slender bone, considered by Müller as the second part of this piece, running backwards along the edge of the parietal. From its apex or inferior point descends vertically the thin Malar bone (u.) to the pterygoid and transverse, having reached which, it sends forward a little process to join the upper jaw-bone. Between the lower and fore part of the anterior frontal and the last mentioned bone is the little Lachrymal bone (t.), which now first makes its appearance as distinct. The Upper Jaw-bones (s.) each send backwards its zygomatic process to join the malar bone and complete the lower edge of the orbit; and in front their ascending sides, with the broad nasal bones, cover the nostrils, of which the large rounded apertures are separated from the mouth only

* Müller has given an excellent paper on the Anatomy, &c. principally of Small Mouthed Snakes, in Tiedemann and Treviranus's *Zeitschrift für Physiologie*, vol. iv. 1831, entitled *Beiträge zur Anatomie und Naturgeschichte der Amphibien*.

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Zoology. by the thin edge of the base of the Intermaxillary bone (r.) which perfects the upper jaw, the whole of which is beset with teeth. The Temporal bone has its Petrous piece (k.) inserted between the sphenoid and occipital, and very slightly, if at all, beneath the hind edge of the parietal: its Squamous piece (l.), now first appearing, is thin and narrow, corresponding in shape to the edge of the posterior parietal process, beneath which it rests, running forwards along the edge of the parietal itself to Müller's second piece of the posterior frontal, but which really seems to be rather part of this Squamous bone: it also stretches back, and curving downwards assisting the Mastoid piece (j.), of nearly the same form, and underlapping it to form the articular surface for the Tympanal piece (m.). The latter piece is vertical and thick above, with a deep notch behind for the reception of the squamous and mastoid points; hollowed on its back and outer face to produce the rudiment of the drum cavity, and thus rendering the outer edge of the bone sharp: the lower end is generally expanded, and forms a convex articular surface (m.*) for the Lower Jaw (v.), which has corresponding concavities; its branches are joined in front, so as to form a single U-shaped piece, and its coronoid processes, not very lofty, are placed in the middle of the bone, and incline slightly outwards.

In the *Skinks*, as *Scincus Officinalis* (fig. 19.), the close immovable connection of the occipital, petrous, and sphenoidal bones (A.) gives the back of the Skull a great resemblance to a verteber. From the fore and under surface of its single Parietal (o.) descend a pair of little pointed processes (B. o. *), to which the upper ends of the columellæ are attached, whilst below they rest upon the pterygoid pieces as these lie on the articular lips of the basilar sphenoid, behind which the pterygoids are grooved to their junction with the tympanal. Does the lower end of the columella traverse in this groove? The upper parts of the temporal pits are covered by the widely expanded posterior frontals (p.†), which run back to the roots of the mastoidal processes, separating the parietal from the squamous temporal bones. Upon the outer end of the transverse bone at its junction with the superior maxillary is an articular surface (B. n.*), upon which the coronoid process of the lower jaw moves, so as it were to form a second maxillary joint.

The Family of *True Lizards* (fig. 20. p.†) have the Parietal bone square, their temporal pits also covered by the extension of the Posterior Frontal; and their Malar bone sending a process backwards, between which and the transverse bone the coronoid process of the Lower Jaw rises. A single genus belonging to this Family, *Zootoco* or *Viviparous Lizard*, exists in this country: it is of small size, and often confounded with the *Salamanders*, but its skeleton shows it to be a true *Lizard*.

In the *Gecko* Family the temporal pits are covered, not by the Frontal, but by the great lateral extent of the Parietal bones, which are a pair; the Malar bone being deficient, so is the hind margin of the orbit; the Transverse bone articulates with the coronoid process of the Lower Jaw; the palatine processes of the Pterygoids and the Palatines themselves are very wide, but do not touch. The tympanal cavity in both the last Families is of increased size.

Among the Family of *Iguanas*, in the *Agamas* (fig. 21.), the Parietal bone (o.), single and square, has its angles largely developed, and, assisting to form the margins of the large orbit, being interposed between the middle and posterior Frontal, which latter stretches back along the upper edge of the large Malar bone, and with it joins the squamous temporal piece, which is widely separate from the parietal, leaving the temporal pit uncovered. In the *True Iguanas* (fig. 5.) the Parietal (o.), wide at its junction with the frontal, is soon pinched up laterally behind, and divides into its large and long mastoidal processes (o †), upon which the mastoid and squamous temporal pieces are attached. Zoology.

The formation of the Lower Jaw (v.) can be well seen in the larger Reptiles, as in *Iguana cornuta* (fig. 32.) joined by bone in front: each side consists of five pieces, the anterior and largest, the dental (1.), supports the teeth: behind it the supra-angular piece (2.) bounding by its hind extremity: the outer edge of the articular cavity for the tympanal bone: between these two pieces, partially seen without (A.), but entirely within (B.), the coronoid piece (3.) rises like a flattened cone on the upper edge of the jaw, and from between it and the supra-angular stretches back the articular (4.), forming the hinder end of the jaw and the articular cavity: the fifth or opercular piece (5.), placed on the inside, connects generally all the other pieces.

The *Crocodile-tailed Teyou*, *Teius Crocodilurus*, is remarkably characterized by the enormous size of its tympanal piece (fig. 22. m.), in which the large drum-cavity closely resembles that of the *Tortoises*.

The Family of *Chameleons* (fig. 4.) have the most oddly-shaped Head of the Saurous Reptiles, consisting of a somewhat pyramidal bony frame-work, with its truncated tip in front, and its base behind. The Frontal bones (p.) run between the large oval orbits which occupy almost the entire sides of the Head, their inferior margins formed by the Upper Jaw-bones (s.), remarkable for being pierced by the nasal apertures, over which, however, are very minute Nasal bones, and scarcely separated in front by a narrow Intermaxillary. In some species, as in the *Bifurcated*, and especially in *Parsons's Chameleon*, each Maxillary and anterior Frontal bone projects an enormously large bony protuberance from its upper surface. The orbital margin is perfected behind by the Posterior Frontal and Malar, and the zygomatic arch by the union of these with the Squamous temporal, which continues beyond the Mastoid piece, curving inwards to meet its fellow; and a long single process (o *), stretching back from the Parietal bone, together forming a frame-work of varying shape and elevation in different species, for the expansion of the superjacent skin. The Mastoid temporal piece (j.) descends nearly vertically, is more or less cylindrical, and has attached to its lower end the vertical, flattened, cylindrical Tympanal piece (m.).

The *Champsian* Order, including the *Crocodiles*, *Alligators* (fig. 7.), and *Gavials*, by the construction of their nasal passages, the articulation of their jaws, and other peculiarities, are so greatly distinguished from the *Saurians*, among which they were included till separated and formed by Merrem into his *Loricate* Order, as fully to justify such re-arrangement.

The Occipital bone (B. c. f.), placed vertically at the back of the Skull, has its large vertebral hole (A. γ.) nearly in the centre: its inferior or basilar piece (1.) descends to the sphenoid bone, upon the basilar piece of which it rests nearly vertical to the palate, with its condyloid process (φ.) divided into two faces by a middle perpendicular groove, jutting from its upper part, and



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a flattened surface below somewhat resembling that of a vertebral body. The sides and upper part of the hole are bounded by the lateral pieces (2. 2.), which, uniting in the mesial line, diverge above, leaving a gap for the reception of the triangular superior piece (3.), and, stretching outwards, are received between the tympanal and mastoid bones.

Of the basilar piece of the Sphenoid bone a very small part only (C. g.) is seen externally, the rest beneath the occipital being concealed by the wide pterygoid pieces (g. †) below it, which form the back of the palate, stretching outwards and downwards with their free extremities distant from the tympanal bones: at their junction behind each is cut out to form the posterior apertures of the nostrils (λ. λ.), which look downwards, are separated from each other by the thin azygos process (f.*), and turn inwards behind so as to render these apertures perfect canals. From above the nasal apertures rise the temporal pieces, which form the under and lateral parts of the Skull; and on their front the orbitar pieces, forming the inner and back part of the orbits, between which is sent forward a compressed process, perfected with membrane, and dividing the orbits from each other.

From the pterygoid pieces stretch forward, beneath, united by their inner edge, the Palate bones (h.): they are flat and oblong, received anteriorly in a wide gap, between the hind part of the upper jaw bones; they occupy the middle third of the palate, and their outer edges curve upwards to the anterior projection of the basilar piece of the sphenoid running between the bottom of the orbits, and with it complete the nasal tubes at this part: projecting still forwards, each divides into two arms; the shorter ascends to unite with the anterior frontal bones, and the longer horizontal one overlaps the palatine process of the upper jaw-bone, which forms, with its fellow, the gap for the reception of the front of the palate bones themselves.

The Parietal bone (o.) is square, flat, and covering the vault of the Skull, its width correspondent to that of the superior occipital: in all the different kinds, except in the *Alligator with bony eyelids*, it is contracted in the middle to assist in forming a pair of holes on the top of the Skull; its sides descend to join with the petrous bone, and with the temporal plates of the sphenoid.

The Frontal bone consists of a middle single piece and two pairs: its middle piece (p.), wide behind, joins the parietal above and the orbitar plates of the sphenoid beneath, with which it perfects the anterior opening of the Skull; it narrows between the orbits, with its upper edge pinched up to form the superciliary edge, and the lower descending to bound the olfactory groove: from the middle of its front edge projects a sword-like process, its tip received within the forks of the nasal bones, and each side connected with the corresponding anterior frontal. The latter (p.*) in front join the nasal, on the outside the lachrymal, and behind descend to the palate bones, forming the anterior boundary of the orbits, and the aperture for the entrance of the olfactory nerves to the nostrils. The posterior frontal (p.†) by its inner edge joins the united outer corner of the middle frontal and parietal, runs backwards upon the sphenoid to the mastoid bone above, and sends a process downwards and outwards to the malar which bounds the orbit posteriorly.

The Lachrymal bone (t.) on the outer edge of the anterior frontal perfects the front of the orbit, and has the nasal duct very distinct on its hinder edge: in front it joins the superior maxillary, and by its outer edge with



The Malar bone (u.), which is paddle-shaped, wide in front as it overlaps the superior maxillary and top of the transverse bone, and stretching back, it forms the lower edge of the orbit, now perfected by its junction with the posterior frontal; the zygomatic process (u.*) juts backwards, thinning beneath the squamous bone.

The Upper Jaw-bones (s.) form the greater part of the roof of the mouth by the junction of their palatine processes, very broad in the *Crocodiles* and *Alligators*, *Champsa*, but narrow in the *Gavials*, *Ramphostoma*, a gap between the hinder ends of which receives the palate bones, and each process is also carved out behind to assist in forming the large oval aperture for the passage of the temporal muscle. The outer edge of the palate is bounded by the thick alveolar process (s.†) supporting teeth, and stretching back is received in the cleft between the transverse and malar bone: from the alveolar the facial process (s.††) inclines upwards and inwards, is of very considerable breadth in the *Crocodiles* and *Alligators*, but separated from its fellow throughout its whole length by the long nasal bones: in the *Gavials*, *Ramphostoma* (fig. 27. s.), on the contrary, it is narrow and thick, separated behind only to a small extent by the short nasal bones, thence joining with its fellow and again separated by the hind extremities of the intermaxillaries.

The Nasal bones (q.), very short in the *Gavials*, form no part of the anterior nasal apertures; but in the *Crocodiles* and *Alligators* are very long, and their pointed front tips are inserted between the intermaxillaries, and assist in forming the nasal orifice. Within cavities of the nostrils the Turbinated bones are placed between the palatine and facial processes of the upper jaw-bones.

The Intermaxillary bones (r.) form the front of the palate by their junction beneath and the common aperture of the nostrils above entirely in the *Gavials* (r.), but in the *Crocodiles* and *Alligators* they are separated by the points of the nasal bones. Their alveolar margin supports teeth, and in the *Crocodiles* a deep indentation (fig. 28. r.) hollows its outer and back part for the reception of the fourth tooth of the lower jaw, so that the bone appears contracted: in both *Crocodiles* and *Alligators* the front of each palatine process is perforated by a hole (r.*) for the lower front tooth, and its inner edge notched to complete with its fellow the single incisive hole (r.††).

The Transverse bones (n.) are T-shaped, the greater part of the stem of each resting in a hollow on the fore and outer part of the corresponding pterygoid bone; the tip of its hinder branch attached to the posterior frontal, and its upper surface to the malar bone, whilst on the outside of the front branch rests the upper jaw-bone.

Of the Temporal bone, the Mastoid piece (j.) perfects the upper surface of the Skull, joining the posterior frontal in front, and stretching inwards at its hind part to join the parietal and complete the large hole on the side of the Skull; beneath it rests on the squamous in front, on the lateral occipital behind, whence it descends on the tympanal piece, and forms the vault of the external auditory passage, of which the floor is made by the following pieces. The Tympanal bone (m.), which

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is the larger of the two, is connected above before and within to the body, pterygoid and temporal pieces of the sphenoid, and as it forms the floor of the auditory passage with the Petrous bone, which projects into the cavity of the Skull, thence continues backwards and downwards, it increases in breadth, stretches beyond and below the outer end of the lateral occipital, and terminates in a convex articular condyle (m.*) of great lateral extent, but compressed from before backwards, upon which the lower jaw moves only vertically. The Squamous piece (l.) is entirely separated from the cavity of the Skull by the tympanal: it passes from beneath the junction of the posterior frontal and mastoid on the fore and outer part of the tympanal piece, narrow at its upper end, widens as it descends, is interposed between the malar and tympanal bones, and rests below upon the outside of the tympanal articular surface, but does not enter the joint.

The Lower Jaw (v.) consists of two branches united by ligament, but not separable, and each consisting of six pieces, the dental forming nearly the anterior three-fifths, and supporting the teeth, the opercular, the angular, the supra-angular, the articular, which forms the articular surface for the tympanal, and the complementary piece, U-shaped, laid on its side, and its bottom received between the upper fork of the opercular. In the *Gavials* the lengthened fore part of the lower jaw consists almost entirely of the dental pieces, the opercular entering only a short distance between them.

The *Chelonian* Order, including *Tortoises* and *Turtles*, is characterized by a long process stretching from the back of the Head, the edges of which in some kinds send out lateral processes to join the temporal bones, and cover more or less perfectly the temporal muscular pits; the cavity of the drum of the ear is also perfectly formed, in shape somewhat resembling a kettle-drum; the margins of the orbits are perfect, and the toothless jaws are overlaid with a sharp hard horny covering, which serves the purpose of scissors.

The Occipital bone (fig. 6. A. B. f.) consists of six pieces: the inferior or basilar (1.) runs into the gap at the back of the sphenoid bone, and upon its upper hind edge is an articular surface beneath the articular surfaces of the two inferior lateral pieces (2. 2.), thus together forming the three-faced condyle (ϕ.) for the spine: the lateral pieces alone rising up form the vertebral hole (γ.); and from their union above springs up the spine (3.), which stretches over several of the anterior vertebrae of the neck, and is itself less or more overlapped in front by the parietal crest, which however, in the *Matamata*, is very short; upon each side of the lateral pieces stretch outwards the superior (4. 4.), or, as Cuvier calls them, the external lateral pieces, between the mastoid and tympanal pieces of the temporal behind and its petrous piece before.

Of the basilar piece (D. g.) of the Sphenoid bone little is seen except a very short triangular portion with its wide base in front of the occipital basilar, in the *Sea-Tortoises* or *Turtles*, *Chelonia*, and the *Land Tortoises*, *Testudo*; but in the *Fresh-water Tortoises*, *Emys* (fig. 26. g.), it is much larger, and in the *Matamata* (fig. 23. g.) still more so, and has the cruciform shape already noticed in *Frogs* and *Toads*: the basilar joins the petrous bones, above and behind, and in front sends up a pair of narrow, nearly vertical temporal pieces, which rest on the front edges of the parietal bones, form the lateral boundaries of the great anterior aperture of the Skull, and separate it from the anterior lacerated holes. The azygos process is entirely concealed by its pterygoid pieces, which, joining in the mesial line, run forwards to the palate and maxillary bones. In the *Matamata*, these pterygoids are of enormous width, and have great resemblance to those of the *Pipa*.



The Vomer (i.) is continued forwards from the pterygoid bones, having the palatine on each side: in the *Tyrse*, *Trionyx Ægyptiacus*, however, it does not extend so far back, but is received into a cleft only between the front of the palatine bones.

The Palatine bones (h.) are generally bounded externally by the projections of the pterygoid which join the upper jaw-bones, but not in *Emys Expansa*, as there is no such junction. In the *Sea-Tortoises* the palate bones, having spread out to the maxillaries, incline horizontally inwards, to each other, and form the posterior aperture of the nostrils, which in them faces backwards, instead of, as generally, on the same plane as the palate itself.

The Temporal bones in front of the occipital bone and the pterygo-sphenoid consist each of four distinct pieces, three forming the side and hind boundaries of the Skull, and the fourth running inwards between the sphenoido-basilar below, and the parietal bone above, extend forwards to bound the hind part of the temporal pit. The external irregular drum-like cavity on the outside of the bone shows the position of the Tympanal piece; in the *Land* and *Fresh-water Tortoises* and the *Matamata*, the margin of the drum cavity is formed by this piece alone, but in the *Sea-Tortoises* and the *Tyrse* another bone assists: from the bottom of the Tympanal piece descends a stout process, having a flat articular surface or condyle for the lower jaw; within, it rests against the pterygo-sphenoid piece, and upon its outer anterior edge is attached the Squamous piece (l.). This, in all the Order, except the *Matamata*, where it is deficient, joins the temporal with the malar bone: it is small in some of the *Fresh-water* and *Land-Tortoises*, and in the *Tyrse*, in which it only assists in forming the zygoma or arch of the cheek, but in others of the *Water-Tortoises*, as *Emys Expansa*, it spreads considerably, rising up to form part of the bony vault of the temporal pit. The Mastoid piece (j.) stretches backwards, overlapping the hinder upper part of the tympanal piece; and if the temporal pit be covered, as in the *Sea-Tortoises* (fig. 6.), or less perfectly in some of the *Fresh-water Tortoises*, it also rises upwards to form part of the bony plate, of which however the principal portion is made up by the transverse pieces (o.*) stretching out from the crest of the Parietal bones (n.), which rises at their junction upon the vault of the Skull, of which they form all the part between the occipital, sphenoidal, and temporal bones.

The Frontal bone of three pairs of pieces, all assisting to form the upper boundary of the orbits, has its principal pair (p.) in front of the parietal, and, except in the *Matamata*, the anterior pair (p.*) are in front of them, bounding the anterior aperture of the nostrils, and joining the upper edges of the maxillary bones, which together form the fore and under part of the orbits; but in that genus, the principal pair extend into the nasal opening, and separate the two anterior pieces. The posterior pieces (p.†) descend from the union of the parietal and principal frontal piece, each connected with the malar bone, which below joins the maxillary, and



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Zoology. perfects the hind under margin of the orbit. If the temporal pit be covered, the malar bone is expanded also to assist in forming the plate, but otherwise it is narrow.

The Upper Jaw is completed in front by the Intermaxillaries (r.), and on the sides by the Superior Maxillary bones (s.), which diverge backwards, including the palatine bones, and generally, though not always, reaching the outer points of the pterygoid bones.

The Lower Jaw consists of a single dental piece (v.) occupying the front, and sending back a pair of branches, the hinder extremity of each cleft externally, and receiving the supra-angular piece, opposite which within is the opercular piece; beneath these is the angular piece completing the under part or base of the jaw. The hind and upper part is perfected by a little flattened triangular articular piece, which is received between the hinder extremities of the opercular and supra-angular, and articulates with the tympanal bone. The coronoid process, the most elevated part, and also a distinct piece, rises upon the upper edge of the jaw, between the dental, opercular, and supra-angular pieces.

3. Of the Ribs and Breast-bone.

In the *Amphibious* and *Batrachian* Reptiles, as the *Siren*, *Eft*, and *Frog*, the Ribs are very small, and seem scarcely more than little bony additions to the transverse processes of the vertebers to increase their length and assist in sustaining the overspread soft parts.

In the *Ophidians* the Ribs (fig. 3. E.) acquire very considerable size and length, their rounded heads having joined the bodies, and their tubercles the transverse processes of the vertebers, they curve around the great common cavity of the trunk, and terminate at the ventral margins in the muscles, as neither breast-bone nor any analogue to it exists. The first pair of Ribs connected with the second, third, or fourth verteber are short; the following pairs lengthen to the thickest part of the animal, whence they gradually diminish, and just behind the vent cease, none existing on the tail. The Ribs swing backwards and forwards upon the spine, with their free ends towards the ground; and these becoming in turn fixed points, the spine swings forward on the Ribs, which are thus the passive organs of locomotion. The Hooded Snakes, *Naja* (fig. 29.), have the anterior ribs of great length, and when at rest folded upon the spine, but when the hood is expanded they stretch out transversely, and sustain it like the framework of an umbrella.

In the *Saurous* Order, the Ribs are connected by their lower ends, either with a breast-bone alone, or the anterior ribs to it, and the posterior to each other, thus forming a more or less perfect framework around the common cavity of the trunk. The Breast-bone consists of two pieces, the body and its handle. The body or hinder piece, generally cartilaginous, is shield-shaped (fig. 19. C. 1.), heart-shaped (fig. 4. A. 1.), diamond-shaped (fig. 30, 31. 1.); it receives on its hinder edges the tips of all the sternal ribs, and on its anterior edges the coraco-clavicular bones, or cartilages. Upon the under surface of the body rests the stem of the second piece or handle (2.), stretching to the throat, and terminating in a T-like head (2.*), of which in the *Iguana* (fig. 30.) the arms are very short, but in the *Ouarans* (fig. 31.) long and curving back like a cross-bow. In the *Skinks* and *True Lizards* the handle has also on each side a transverse process (2.*), producing a crucial appearance, the ends of which nearly or quite reach the blade-bones. The stem of this process is evidently that which in Birds will be found fully developed in the keel of their breast-bone. In the *Chameleons* this process does not exist, and the Breast-bone (fig. 4. A. 1.) reduced to a triangular, or rather heart-shaped cartilage, has its point forwards, its sides connected to the coracoid bones, and from the cleft in its base a straight cartilage runs back, on the sides and ends of which all the sternal ribs are attached, whilst those subsequent unite with their fellows, each pair forming a loop directed forwards to the mesial line. Zoology.

The *Dragons*, *Draco*, are remarkable for the lateral extension of some pairs of their posterior ribs (fig. 33.) between doublings of the skin, so as to produce the appearance of a pair of flat wings.

In the *Crocodiles* it has been usual to divide the Ribs into cervical and dorsal; the so-called cervical ribs are, however, really the vertebral transverse processes, of which the ends each give off a short arm stretching forwards, and a long one backwards, to increase the levers for the muscles. Of the Ribs the greater number are attached to the Breast-bone, but some few hinder pairs float loosely in the muscles. The Breast-bone (fig. 7. D. 1.) consists of a simple diamond-shaped cartilage, underlapped by a dagger-shaped bone (2.), the front of which projects beyond its truncated anterior angle, whilst from its posterior end a lengthy cartilage (3.) stretches, to which some of the ribs are attached, the rest being fixed against the posterior edges of the shield, as the coracoid bones are to the anterior edge. Pairs of cartilages extending from the mesial line outwards and backwards along the whole under face of the belly, are merely bony or cartilaginous developments of the intermuscular segments requisite for enabling the abdominal muscles to support without inconvenience the bulky contents of the belly of these animals.

In the *Chelonian* Order the Ribs and Breast-bone, especially the former, are largely developed, forming a less or more perfect bony case for the whole trunk, within which the head and limbs can be more or less completely retracted, and consisting of two large shields or plates, the upper shield, or carapace, formed by the junction of the expanded ribs (fig. 6. E.) with the hexagonal terminal expansions of the spinous processes of the back vertebers, which cover the ridge of the back; and the under shield, or plastron, consisting of the breast-bone.

The Carapace (ε. ε. ε. ε. β. β. β. β.), vaulted in every direction, is in the *Water-Tortoises* least, and in the *Land-Tortoises* most elevated. Externally the connection of the Ribs with each other and with the spinous processes is marked by close seams. Internally each rib (fig. 6. β.) unites by a distinct head to a corresponding articular cavity formed by two adjoining vertebers, and having reached the lateral edge of the expanded vertebral spinous process, itself expands anteriorly and posteriorly to join the adjacent ribs; but the body of each is discernible throughout its whole length. The extent of this widening varies: in the *Land-Tortoises* it is continued to the very tip of each rib, but in the *Water-Tortoises* their tips are free (fig. 6.). In the *Tyrse* these free tips do not reach the circumference of the animal, which is cuticular. But in the so-called *Soft Tortoises* a peripheral cartilage exists, into which the outer ends of the ribs are received; and in the *Sea-Tortoises* this cartilage is replaced by a series of trigonal bones

($\epsilon. \epsilon. \epsilon. \epsilon.$) with the base inwards and the thin edge outwards, consisting of eight pairs, correspondent with the number of ribs, and other three pairs and two single pieces to complete the bony margin. The anterior single piece ($\epsilon.$*) is wide from side to side, connected behind with the first dorsal spine and first pair of ribs; its anterior angles join the first pair of marginal pieces, which, as well as the second pair, receive no ribs, but simply with the single piece complete the front of the bony margin. The posterior single hexagonal piece ($\epsilon.$†) is connected with the dorsal spines by the intervention of two bony plates, of which the second is a truncated pyramid, with its base forwards and the first hexagonal as the other spinal plates: the sides of this single piece are connected by a pair of marginal bones not receiving ribs to the last pair which do. The series of peripheral pieces are held by Cuvier as analogous to the cartilages of the breast-bone in Birds and Beasts. In consequence of the projection of the unexpanded extremities of the ribs, spaces remain, in the *Water-Tortoises*, between them and the marginal pieces, which are filled up with strong ligament; but in the *Land-Tortoises* such ligamentous spaces do not exist, the ribs being expanded throughout to their junction with the marginal bones.

The Plastron ($\pi. \pi.$), nearly flat, consists of four pairs of pieces and a single piece, which are very distinct in the *Sea-Tortoises*. The anterior, or throat pair ($\pi.$*), join in front, and from thence curve backwards and outwards; the single straight piece ($\pi.$‡) stretches back, and the three together recall the cross-bow shape of the sternal bone of the *Iguanas*: in the *Tyrse*, however, the single piece is deficient. The two middle principal or connecting pairs ($\pi. \pi.$) are irregularly square, and closely united by suture; each sends one broad, jagged process outwards to join the marginal bones, and another short, jagged piece towards towards the mesial line; the inner anterior ends of the first pair stretch forwards within the extremities of the throat pair; the inner posterior ends of the second pair are received within the extremities of the hinder or vent pair ($\pi$†), which are sword-shaped, and join by their tips in the mesial line. Excepting in front and behind, these pieces are separated by a longitudinal gap, and a gap exists on each side between the connecting pieces and marginal bones. But the spaces vary, for in the *Tyrse* the lateral spaces do not exist, its outer jagged processes being very short; and in the *Land-Tortoises* there are not any, the whole plastron being bony, the eight pieces of which it consists joining each other by nearly straight edges: their middle or connecting pairs are also distinguished by sending up from each corner of the central square plate which they form, a vertical process to join the interior of the Carapace, thereby considerably strengthening the close, seamy connection of the outer edges of the central plate with the margin of the Carapace. The spaces between the Plastron and Carapace before and behind remain always open in the *Water-Tortoises*, and in some of the *Land-Tortoises*, but of the latter there is a section called *Box Tortoises*, in which the anterior or posterior pair of sternal pieces move by a ligamentous hinge upon the central connecting plate, and being elevated to the Carapace either before or behind, close the corresponding aperture.

4. Of the Locomotive Organs.

All Reptiles, except the Ophidian, are provided with limbs, generally both anterior and posterior, but in some instances fore limbs only, and in others hind limbs only exist, and in a few such limbs are merely rudimental, and either apparent or concealed beneath the skin.

A. The *Fore Limbs*,

Include the shoulder-girdle and the arms or fore legs; the former connecting the latter to the trunk either by bony articulation or by muscular suspension.

The *Shoulder-Girdle* consists either of a pair of cartilages or of two pairs of bones, the analogues of the latter being distinguishable in the former.

In the Family of *Efts* (fig. 9. D. E.) and *Salamanders*, each cartilage consists of a horizontal or clavicular portion (4.) stretching inwards under the trunk, one above the other, and a vertical or scapular portion (5.) inclining inwards and upwards towards the spine, but neither articulates with the trunk: each portion is thin and wide from before backwards at its free extremity, but narrowing and thickening where they meet, are hollowed out into an articular socket for the head of the upper arm-bone.

In the *Frogs* (fig. 1.) and *Toads* the Shoulder becomes bony and firm, the part forming the articular cavity large and thick; the horizontal portion (D. 4. 4.*) bifurcates into two distinct branches, which run inwards and articulate with the breast-bone; the hinder one (4.*) is considered to be the Coracoid process of the Blade-bone, and the front one (4.) the Clavicle: the vertical portion or Blade-bone (5.), slender and narrow below, is much enlarged by a wide cartilage at its upper end or base, which curves nearly to the spine.

Among the *Saurous* Reptiles, the Shoulder of the *Chameleon* is very simple, and of two pieces only, their hinder junction is hollowed out to form the articular cavity for the arm; their regular, square, horizontal bone, or Clavicle (fig. 4. A. 4.) is fixed by its inner edge to the side of the breast-bone; and the vertical Blade-bone (5.) is widened in front of the articular cavity to form its acromical process.

In the *Skinks* (fig. 19.), *Iguanas* (fig. 5.), *Lizards* and *Ouarans*, both the Coraco-clavicular and Blade-bones are considerably expanded, especially the former, which joins the sternal cartilaginous shield and its cross-bow bone, resting also upon the transverse piece of the latter bone, if so furnished as in the *Skinks*. In the Coraco-clavicular bone are two perforations, of which the larger front one has the so-called Clavicle (6.*) on the fore and outer, and the Coracoid bone (6.) on the back and inner part, but without any distinct separation. The true Clavicle, however, is certainly the piece (4.) which, in the *Iguana*, passes from the front of the transverse arm of the breast-bone handle, where it unites with its fellow, to the front of the blade-bone. In the *Skinks* (fig. 19 C. 4) and in the *True Lizards*, this bone is large and wide, with a large aperture near its inner end.

In the *Slow-worm* (fig. 18. C.) and its congeners, rudiments of the fore limbs exist in the Shoulder-Girdle, which is alone present, but from its delicacy found with great difficulty. Meckel describes it as consisting of three pieces, and forming on each side a semicircular band; the under or Clavicular piece (4.) is oblong, square, and inclines anteriorly towards its fellow without uniting to it, but joins the edge of the breast-bone; the upper or Scapular piece (5.) is also square, but very small; in front of the clavicle is a slender S-shaped piece (6.) passing from the blade-bone across to its fellow. In the *Ophisaurus* these bones are larger, but the breast-bone is deficient. In *Bipes* a breast-bone exists, but no Shoulder-Girdle; and in *Acontias* neither one nor other.

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In the *Crocodile* Order the Shoulder consists of only two pieces, the Blade-bone (fig. 7. 5.) and the Coracoid bone (E. 6.), which so closely correspond in shape, the former being only longer than the latter, that an old writer has described the *Crocodiles* as having two blade-bones.

In the *Tortoises* (fig. 6.) the form and disposition of the pieces of the Shoulder are so remarkable that they seem formed upon a peculiar type, and scarcely comparable with the same part in other Reptiles; hence has arisen the difference among zootomists as to the determination of their pieces: thus. Cuvier disallows the existence of a clavicle, and describes the vertical angular piece interposed between the carapace and plastron, as the blade-bone (5.), all above the articular surface (χ.) being the body, all below the acromial process (4.) of the bone, and the flattened piece stretching backwards its coracoid process (6.). Bojanus, on the contrary, holds the vertical angular piece to be the clavicle, consisting of an upper and lower branch, and the posterior horizontal piece to be the blade-bone. On comparing the Shoulder of the Tortoises with those of the *Lizard-like* Reptiles, it will, however, be very readily perceived that the typical structure of this Class is distinctly and readily traceable; the seeming discrepancy arising only from the peculiar development of the breast-bone in the *Tortoises*. The anterior vertical piece of the Shoulder in the *Chelonians* consists of two branches, which join at an angle, from the exterior of which juts out a process with its end hollowed to form part of the articular surface for the upper arm: the branch (5.) above the articular cavity, connected by its upper end with the side of the second dorsal verteber, can be no other than the Blade-bone. Bojanus speaks of a little triangular bone between it and the verteber, in the *European Fresh-water Tortoise*; but Cuvier has never seen it, and denies its existence in any other genus: the lower branch or Clavicle (4.) is connected below with the anterior angle of the single sternal piece, as in the Lizard-like Reptiles; and Cuvier's observation that in young *Marine Tortoises* he had occasionally seen the two branches divided by a distinct suture, although he had never noticed it in Land-Tortoises however young, still further supports this view. The horizontal posterior piece stretching backwards and inwards is the Coracoid bone (6.), short and triangular in the *Land-Tortoises*, long and paddle-shaped in the *Marine Tortoises*, in both its widest part is posterior, and its thickest anterior, with the extremity hollowed, and joining the blade-bone to perfect the articular cavity: a strong ligamentous band stretches from the inner angle of its base to the lower end of the clavicle, and if this be undisturbed, the whole apparatus has a very near resemblance to the Shoulder of the *Skinks*.

*The Fore Leg, or Arm*, consists of an upper-arm bone, two fore-arm bones, and the foot or hand bones, varying in number in different kinds of Reptiles.

The Upper Arm is always a single bone, when at rest, more or less horizontal, with the elbow behind and the shoulder-joint in front, except in the *Tortoises*, which have the elbow forwards and the shoulder behind. In the *Amphibious* Order, as in the *Siren*, *Proteus*, &c., the Upper Arm is very short, its head flattened, of a hemi-spheroidal form, and its short axis from within outwards. Among the *Batrachians* (fig. 1. 7.) the *Frogs* and *Toads* have the head roundish, and on the fore and under part of the shaft is a sharp muscular ridge; the lower end of the bone has a hemispherical articular surface, bounded on the inner edge by a little projecting condyle. In the *Salamanders* and *Tritons*, on each side, just below the head, is a little tubercle, one rounded, the other angular; and the lower has a rounded articular surface for the fore-arm.

Among the *Saurous* Reptiles the *Skink* has the anterior end of the bone very wide, with a semiovaloid head, looking upwards: a strong tubercle projects from it inwards, and a smaller one outwards and downwards; the hinder end has, between two distinct condyles, a double pulley, of which the outer is largest, for the spoke-bone.

The *Crocodiles* have the shaft of the Arm-bone (fig. 7. 7.) slightly curving and twisted from without inwards; its anterior end, very wide and flat, is nearly covered with a slightly rounded articular surface; the posterior end has two rounded articular surfaces, looking downwards and separated by a depression; a ridge upon the outer under surface, near the head, has a resemblance to that in *Frogs*.

The position of the Upper Arm (fig. 6. 7.) in the *Chelonian* Order, viz., its extension forward instead of backward, distinguishes it not only from all other Reptiles, but indeed from all other Vertebrate animals, entirely reversing its several parts, so that those in other instances in front or to the inner side, are here behind and to the outer side. In the *Land-Tortoises* the whole bone is more cylindrical, but in the *Marine* especially more flat and expanded; and in the former also arched, with the hollow facing downwards, in the latter nearly straight. From the upper surface of the hinder end rises up a well-defined semi-globular head to be received into the socket of the shoulder; the great tubercle (here the outer) stretches backwards and to the outside of the head, is largest in the *Marine Tortoises*, in which it is compressed laterally and has great resemblance to the olechranon of the fore-arm in Beasts and Man; the little tubercle is, on the inside of the head, nearly on a level with it in the *Land*, but in the *Marine Tortoises* below and before it, and a large pit exists beneath between the head and the tubercles. The anterior extremity has in the *Land-Tortoises* a pair of rounded articular surfaces for the fore-arm separated by a depression, but in the *Marine* there is only one wide articular surface for the same purpose; in both, they face forwards and downwards.

The Fore-Arm, in all except the *Tail-less Batrachian* Reptiles, consists of two bones, in a state of pronation, *i. e.* the one bone to which the hand is more especially connected, so twisted over the other, that the palm is applied to the ground, becoming the sole of the fore-foot. Although, however, in *Frogs* (fig. 1. 8.) and *Toads*, the Fore-Arm has but a single bone, the upper end of which is certainly the Cubit, with its sigmoid articular cavity for the upper arm, bounded posteriorly by the lofty olechranon, yet does its lower flattened end exhibit on each side a groove marking the separation between the Cubit and the Spoke-bone, both of which assist in forming the wrist joint. In the *Amphibious* and in the *Tailed Batrachian* Reptiles, the Cubit and Spoke-bone are of nearly equal length, and somewhat flattened; their articular extremities generally cartilaginous, and no distinct olechranon to the former. In the *Saurian* Order (fig. 5. 8.), the bones of the Fore-Arm are distinct and well developed, the Cubit has a distinct olechranon, but the principal connection with the upper arm is by the cupped head of the Spoke-bone. In the

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*Crocodiles* (fig. 7. 8.) the Cubit has no olechranon, but is much larger than the Spoke-bone, and its articular surface for the upper arm is the largest. In the *Chelonian* Order, the *Land-Tortoises* (fig. 25. B. 8.) have their Cubit and Spoke-bone massive in comparison with their size on the same plane, of nearly equal length, the olechranon of the former rising above the head of the latter, but the base or lower end of the latter descends below the Cubit. The *Tyrse* has not any olechranon, and the Spoke-bone inclines behind the Cubit, so that part of its base is overlapped by the latter. These points are still more remarkable in the *Marine Tortoises* (fig. 6. 8.), in which the long and slender Spoke-bone behind the Cubit throughout its whole length descends also behind the first row of the wrist bones.

The Wrist, *carpus*, consists of numerous small bones, varying in number in the different Orders: in the *Batrachian* Reptiles seven, in the *Saurous* and *Chelonian* nine, and in the *Champsian* four: in all the upper row consists of but two, or at most of three bones, one articulating with each bone of the fore-arm, and the third projecting from one side of the Wrist. In the *Crocodiles* (fig. 7. 9.), one large and long bone is interposed between the spoke-bone and hand, but between the cubit and hand are two, of which the upper is longest; the fourth bone is attached to the side of the base of the cubit. In the *Land* (fig. 25. 9.) and *Fresh-Water Tortoises*, the cubit and spoke-bone each are connected to a single bone, and upon the upper junction of these Wrist-bones a little bone is placed and insinuated between the bases of the fore-arm bones, to such extent indeed in the *Fresh-water Tortoises* as to separate them from each other. In the *Tyrse*, the cubit is joined directly with two bones, and the spoke-bone rests upon the inside of the inner, but in the *Marine Tortoises* is placed actually behind it. In the *Land* and *Fresh-water* kinds the remaining bones are in one row; but in the *Tyrse* two, one of which joins the spoke-bone, are interposed between the inner bone, joining the cubit and the lower row, and the ninth little bone projects on the outer side of the Wrist: this (fig. 6, 9.*), in the *Marine Tortoises*, is of considerable size, and greatly increases the breadth of the hand.

The Palm of the hand, *metacarpus*, consists generally of five bones, of which that of the thumb is rather thicker and shorter than the rest; each of these supports a finger of three joints, excepting one (the thumb), which has only two. Among the *Amphibious* Order, the *Proteus* has but three, and the *Siren* four fingers; in the *Tailless Batrachians* the thumb is rudimental. The *Salamanders* and *Efts* have three fingers and a thumb. The *Saurous* Reptiles, with some few exceptions, have five fingers, all directed forwards, but in the *Chameleons* (fig 4. 11.) they are disposed in two packets like carpenters' pincers, of which one claw is formed by three on the inner and fore part, and two on the outer and back part, which are capable of being brought together to grasp completely. The five fingers of the *Crocodiles* are all in front, as also are those of the *Chelonian* Order, but there is a marked distinction between the *Land* and *Water-Tortoises*, and specially the *Marine*. In the *Land-Tortoises* (fig. 25. 10.), the wrist, palm, and finger bones are all short, vertically upon each other beneath the fore-arm, and included in a sort of skinny boot: in the *Water-Tortoises* the palm and finger bones are longer, and the latter separate from each other; but in the *Marine Tortoises* (fig. 6. 10.) the fore-arm and whole hand are nearly horizontal, flattened, expanded, enveloped in tough fibrous structure, and overspread with flat horny plates, entirely concealing the bones, so as to form very large paddles

B. The *Hind Limbs*

Consist of the hip-girdle and hind legs.

The *Hip-girdle* differs from that of the shoulder in being always connected with the transverse processes of one or more vertebers, which in Birds, Beasts, and Man, form the rump-bone. The other bones of the Girdle are either one, two, or three pairs, sometimes separate, but at other times ossified together so as to form a single pair, one on each side and on the under part of the Girdle, and are commonly called the unnamed bones, and the pieces of which each consist are described as the hip, haunch, and share-bones.

In some *Amphibious* Reptiles, as the *Siren*, no trace of the Hip-girdle exists; but the *Proteus*, according to Cuvier's description, has a Hip-Girdle almost entirely cartilaginous, a little earth existing only in the cylindrical Hip-bones, which are elongated upwards by an expanded cartilage for connection with the adjacent verteber. In the *Menopome*, and also in the *Common Salamander* and *Newt* among the *Tailed Batrachians*, the penultimate pair of ribs are wider than the others, and to their expanded tips are attached the long Hip-bones which join below with the Haunch-bones to form the joint-cup for the thigh-bone. The Haunch-bones stretch backwards, uniting with each other in the mesial line, at an acute angle; and in front of their union with the Hip are the cartilaginous Share-bones. But in the *Tailless* Batrachians, as *Frogs* and *Toads*, the Hip-bones (fig. 1. E. 12.) are very long, stretch back, and form nearly one-half of the total length of the animal; they are cylindrical, slightly compressed, curve down, approximate behind, and becoming massive, are hollowed out to form with the Haunch-bones (13.) the cup of the Hip-socket; behind and below which the latter are compressed and consolidated into a single piece depending like a circular keel. A very slight indication of Share-bone (14.) is discernible in *Frogs*, in the little bony band above the shallow depression existing on each side of the keel in front of the Hip-socket, but in *Toads* this is not visible.

The whole Order of *Ophidian* Reptiles are devoid of any Hip-Girdle.

In the *Saurians* the Hip-Girdle can be traced from a very simple to a well developed form. In the *Slow-worm* (fig. 18. D.) it is merely rudimental, consisting of a pair of reversed T-shaped bones; the stem (a.) of each attached by its upper extremity to one of the hinder vertebral transverse processes descends obliquely forwards and downwards to its horizontal part (b. b.), which is widely separate from its fellow, and has its anterior branch much longer than the posterior.

In the *Chameleons* (fig. 4.), the development is much advanced, but the Hip-Girdle is still very simple; the Hip-bones (12.) are lengthy, but compressed and broad above at their junction with the transverse processes of two vertebers; descending, they converge and narrow from before to behind, and thicken below at their union with the Share (14.) and Haunch-bones (13.), to form the articular cup. The latter bones unite with their fellows at an acute angle in the mesial line, but a large gap separates one pair from the other.

In the *Skinks* these bones are nearly the same, but of greater length; the upper end of the Hip rises above

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the spine; and the whole length of the Share-bone is flattened from before backwards. This flattening increases in the *Geckos*, which have an angular projection outwards of the Share-bones as they descend inwards and meet each other. In the *Iguanas* (fig. 5.), the expansion of the Share-bone is proportionally greater; their Hip-socket is very shallow, and faces backwards and outwards, as indeed it does more or less in all the *Saurous* Reptiles.

In the *Crocodiles* (fig. 7) the Hip-bone is T-shaped (12.), the transverse branch articulating with the broad transverse processes of two vertebers, and the lower end expanding to form the upper part of the Hip-socket, which is perfected below by the Haunch-bone. The latter bone (F. 13.) descends, expanding towards the mesial line to join its fellow, and having in front a process to which is attached the thick handle of the paddle-shaped Share-bone (14.), which does not assist in the formation of the Hip-joint, but stretches forwards and inwards, receiving upon its broad front one of the first pair of bony pieces (*r. r.*), of which many are placed between the sections of the *rectus abdominis* muscle, even to the breast-bone.

In the *Land* and in the *Fresh-water Tortoises*, the Hip-bone is connected by its upper end to the transverse processes of two vertebers, and slightly also to the superjacent carapace; but in the *Marine Tortoises* (fig. 6. 12.) the latter connection is more extensive; and in the *Matamata* (fig. 23. 12.*) the upper end of the bone is expanded like a mushroom, and immovably fixed to the carapace: in all the lower end of the bone is hollowed on the outside to assist in forming the hip-socket with the other two bones. The Share-bone, in the *Land* and *Fresh-water Tortoises*, having formed the under and fore part of the Hip-socket, stretches forwards in the former into a projecting pointed, and in the latter a projecting blunt process; thence spreads inwards, widening as it approaches to join its fellow, is somewhat hatchet-shaped, with a concave edge in front, and a similar one behind; the posterior angle of the hatchet is truncated to join the Haunch-bone. In the *Tyrse* and in the *Marine Tortoises* the Share-bones do not join the Haunch-bones, the hatchet-shaped expansion of the latter being principally forwards, whilst in the former the expansion is nearly equal in front of the joint piece, and resembles a broken spade. The *Matamata* (fig. 23. 14.*) has the external angle of its Share-bone remarkably developed and bulky to connect it with the plastron by a broad surface; its hatchet-shaped part does not join with that of the corresponding bone, nor has it any connection with the Haunch-bone. In the *Marine Tortoises* the share-bone (fig. 6. 14.*) is a nearly straight narrow flattened transverse bone, with expanded ends, the outer forming the under part of the Hip-socket, and the inner joining with its fellow backwards; a large half oval aperture is left between the Haunch and Share bones. In the *Tyrse* the hole is of a more circular form, in consequence of the Haunch-bones curving backwards and inwards to their junction. In the *Fresh-water* and *Land-Tortoises*, the transverse Haunch-bone sends a process forwards to connect it with the truncated angle of the hatchet-shaped process of the Share-bone, and thus there is left, by the union of the two pairs of bones, a pair of oval apertures. In the *Marine Tortoises* the Haunch-bone (13.) simply crosses to join its fellow, but except at the Hip-joint has no connection with the Share-bones, a large gap remaining between them. The *Matamata* (fig. 23. 13.*) is here again very peculiar, its Haunch-bone descending vertically from the Hip-socket, and becoming connected by its broadly expanded lower end to the plastron; its Hip-Girdle is therefore completely fixed, and cannot be swung backwards and forwards as in the *Land* and *Fresh-water* kinds, or even allow of a slightly yielding motion as in the *Tyrse* and *Marine Tortoises*.

The Thigh-bone (15.) is cylindrical, nearly straight in all Reptiles, except in the *Crocodiles*, in which it is curved somewhat like an italic *f*. Its articular surface or rounded head, received into the Hip-socket, in *Frogs* and *Toads*, forms more than half a sphere, and faces almost directly backwards, but in the *Saurous* and *Champsian* Orders also upwards. The only process upon the hinder part of the bone in *Frogs* and *Toads* is a sharp ridge, similar to that on the arm-bone; but in the *Saurous* Reptiles this projects inwards, and has some resemblance to the lesser trochanter of Beasts. The anterior extremity of the Thigh-bone spreads into condyles or pulleys on which the leg moves, and in some of the *Saurous Reptiles* has a remarkable depression on the outer condyle for the head of the splint-bone; but no such hollow is observed in the *Crocodiles*. In the *Chelonian* Order, the Thigh-bone is generally shaped like an italic *f*, except in the *Marine Tortoises*, which have it nearly straight; but in all it is distinguished by the great development of the head, which is placed nearly at right angles with the shaft of the bone, supported by a more or less well defined wide neck, and its convexity facing much more upwards than in either of the other Orders; the hinder end of the shaft spreads outwards beneath the head to form the broad great trochanter, and the little trochanter stretches inward from the neck: these processes are more distinct in the *Tyrse*. The anterior end of the bone is a simple wide pulley, on which both bones of the leg move. The only material difference between the several kinds is, that in the *Marine Tortoises* the form of the bone is less sharp.

The Leg (16.) in the *Tailless Batrachian* Reptiles is rather longer than the thigh, and consists of two bones coalescing together in the middle of their shaft as in the fore-arm; the upper end is hollowed for the condyles of the thigh, and the lower end wide and pulley-shaped for the wrist-bones. In the *Tailed Batrachian*, and in the *Saurous* Reptiles, the two bones of the leg are distinct: the inner larger one is the Shin-bone, somewhat prismatic, with its upper end or head expanded to form the principal junction with the thigh-bone, and its lower end or base expanded to join the instep-bones. In the *Chameleons* the head of the Shin-bone has but little concavity for the thigh, and therefore motion is very free at that joint. In the *Chelonian Reptiles* the Shin-bone is much the larger, its articular ends nearly flat, and the ridges on the bone are sharper in the *Land* than in the *Marine* kinds. The Splint-bone is slender, but thickening and becoming prismatic at its lower end.

The Foot (17.) consists of instep, sole, and toe-bones; in the *Proteus* the instep, *tarsus*, and sole *metatarsus* are little more than a mass of cartilage, to which are attached a pair of toes with three joints, but in most others the instep and sole are distinct. The *Tailless Batrachian* Reptiles have only two in the first row, of considerable length, and simulating the appearance of the bones of the leg. In other Reptiles the inner one supporting the thumb is considered to be the astragalus,

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and the outer the heel-bone; and between these and the sole are placed five comparatively very small bones. The sole and toe-bones have great resemblance to those of the fore-feet; but to the inner instep-bone is attached a remarkably broad bone, which is believed to be a rudimental sixth toe. The *Saurous* and *Champsian* Reptiles have but four instep-bones, two in the first row, short and wide, and two smaller ones in the second, supporting the sole bones of the fourth and fifth toes, the latter of which in the *Crocodiles* is merely rudimental. The *Chameleons* have both bones of the first row articulated with a spherical bone, which below is connected with two other rather long ones on the inner and two on the outer side, and behind with a short bone, to the outer side of which is attached another long one; all five of this third row are joined to corresponding sole-bones with their toes, which are therefore two within and three without. Among the *Tortoises*, the *Land* kinds are distinguished by their short and transversely flattened instep-bones, and by the very short sole-bones and toes, the extreme joints of the latter being like the little bones of Hoofed Beasts: whilst on the contrary, in the *Fresh-water Tortoises*, all these bones are more lengthy, and in the *Marine* kinds flattened.

Among the *Ophidian* Order some few have rudimental hind limbs on each side of the vent, but unconnected with the spine, and devoid of hip-girdle or thigh. In the *Boæ* they are a pair of claws, which envelope correspondingly shaped little semicartilaginous bones, each supported by a curving bone (fig. 34. a.), with a little stumpy process on its inner side (a.*), attached by its upper end to another bone three times as long (b.), which projects on each side of its articular surface a little process (b.* b.*), and has its upper end (b.†) loose among the muscles. These bones Mayer considers analogues, the larger one of the shin-bone, and its two little processes as instep-bones, the smaller one as the sole-bone, and the extreme piece as a toe with a single joint: it would seem preferable however to consider them simply as the joints of toes. Similar claws also exist in *Eryx*, *Python*, *Clothonia*, and also in *Tortrix*; but this last is remarkable for the concealment of the claws within little depressions in the skin covered with scales close to the vent.

### Of the Skeleton of Birds.

The bones of Birds have their shell generally of close texture, thin, and very brittle, and the cavities of many, especially among the Land Birds, filled with air, by which their specific weight is considerably diminished, and thereby less muscular exertion required in flight. The air pervades more or less perfectly the bones of the head, trunk, and the first member of the wing; but the legs are commonly filled with fat.

When at rest, the trunk is supported on the legs alone, and upon these it moves in walking, hopping, climbing, or swimming; but these are not employed in flying, which is the peculiar characteristic of the Class of Birds, and effected by the anterior extremities, or wings, which are specially developed for that purpose, as, indeed, is also the whole construction of these animals.*

* The general description of the bones is from the Common Fowl (fig. 6.), except otherwise expressed.



1. Of the Spine.

The Spine of Birds is formed on one uniform type, varying only in a few unimportant particulars. It is distinctly divisible into Neck, back, hip-girdle, and tail, and each of these regions have peculiar characters. The Neck has great length and mobility enabling the bird to collect its food from the ground without squatting: it is therefore always of equal length with, sometimes even longer than the legs, and is movable in every direction to enable the animal to carry its head, to a certain extent, in any direction without actual movement of its feet from the position they occupy. Its vertebral pieces are connected by true joints, their corresponding surfaces being overlaid with cartilage and enclosed in loose fibrous capsules, lined with synovial membranes. The vertebers of the Back have either true joints or are more or less united by bone, but their processes are so arranged as almost entirely to preclude motion, the use of this region being to furnish not only a fixed point on which the neck may move, but also on which the bones of the chest may be so firmly suspended as to provide a fulcrum upon which the motions of the wings may be efficiently performed. The loin and rump vertebers are consolidated, though still distinguishable, into a single Girdle-piece, not unfrequently united by bone to the back in front, and to the hip-bones on the sides, so as to strengthen the hip-girdle in forming a lever, by means of which the heavy trunk is moved upon the fulcra of the thigh-bones. The Tail is made up of movable pieces, connected by fibro-cartilage, and furnishes a powerful but movable lever to operate in the rudder-like motions of the feathery tail.

The *Neck*, from its greater length, consists of more vertebers than either of the other regions of the Spine. The number varies in different kinds of Birds, from ten to twenty-three, as in the *Cape Penguin*, *Aptenodytes demersa*, and in the *Yellow-beaked Swan*, *Cygnus musicus*, which are the extremes, but most commonly from ten to fifteen; and in a few, to eighteen or nineteen. The Neck vertebers together form a double curve, like the letter S, the upper facing forwards, and the lower backwards, by increasing or diminishing which the neck is shortened or lengthened. The body, or front of each verteber (fig. 6. A. a.), is either square, trigonal, or somewhat cylindrical; it is short in Birds with short necks, as the *Sparrow*, *Fringilla domestica*, *Pigeon*, *Columba œnas*, &c., and lengthy in such as have the neck long, as the *Heron*, *Ardea cinerea*, &c., of which the faces are more or less hollowed transversely. Its upper end has an articular surface (h.), concave from side to side, and convex from before backwards; but at the lower end the concavity and convexity of the articular surface (c.) are reversed, which admits a kind of restricted rotatory motion between two adjacent vertebers. The arch (B. d.) enclosing so much of the great vertebral canal (ϕ.) as each bone forms, has behind a vertical ridge (e.), forming, according to its development, a more or less distinct ridge, or protuberance, which is the spinous process. At the junction above of the arch with the body, a pair of superior articular processes (f.) stretch outwards and backwards, their articular faces nearly flat, with a slight central concavity inclined towards each other. From each of these curves forward to the front edge of the body the transverse processes (g.), a pair of more or less deep bony collars, lengthening below for the attachment of muscles, and each perforated by a canal (*) for the vertebral artery and



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sympathetic nerve. Occasionally their projecting forwards is so great as to form a wide gutter on the front of the verteber, as in the *Common Fowl*, *Gallus domesticus*, and *Turkey*; or they even unite and produce an anterior collar, as in the *Gannet*, *Sula alba* (fig. 26. †), and *Pelican*, *Pelicanus onocrotalus*. The lower end of the arch divides into two strong inferior articular processes (A. B. h.), descending below the body, with their slightly concave articular surfaces facing outwards, and received within the corresponding subjacent processes. The uppermost two vertebers are specially distinguished from the rest. The first, or Atlas, has at the upper or anterior end of its very shallow body a more or less deep cup-like cavity (fig. 6. C. a.*), for the single occipital condyle; its under end has a semilunar articular surface for the body of the subjacent verteber; and within its concavity behind is a deep hollow (c.*) for the pivot process of the same bone. From its lower and front edge a little process sometimes descends to clasp the top of the second verteber, as in the *Rapacious* Order. The vertebral hole ($\varphi$.) is very large, and the ring by which it is formed very thin, but more or less deep, and sends down a pair of little inferior articular processes. The second verteber or Pivot has on the upper end of its body, in front, a semilunar articular surface (fig. 6. D. a.*), behind which rises up its little pivot (b.*), upon and around which the Atlas moves. The lower end of the bone has a similar articular surface to that of the other vertebers, but projects a more or less strong anterior spinous process (i.), to which the muscles bowing the neck forwards are fixed. The arch (d) of this bone, together with its long spinous process, is very bulky, and, in comparison with its size, is the most massive among all the vertebers, on account of the numerous extending muscles attached to it. Sometimes two or three of the subjacent vertebers have anterior spinous processes, which gradually diminish in size till they disappear; and not unfrequently some of the lower vertebers are similarly furnished.

In the *Back* the ordinary number of vertebers, which are nearly horizontal, with their ends facing backwards and forwards, is seven or eight, but some Birds, as the *Grebes*, *Podiceps*, *Divers*, *Colymbus*, *Guillemots*, *Uria*, &c., have ten, and the *Yellow-beaked Swan* and *Cassowary* eleven. Their bodies (E. a.) are more cylindrical, or even compressed with nearly flat ends admitting of little motion; their articular processes (f. h.) smaller, and gradually lessening as they run further back; their deep spinous processes (e.) distinct; and their broad, horizontal, transverse processes (g.), each with an articular surface on its end ($\beta$.), for the tubercle of the corresponding rib, of which its head is received in a small shallow cup ($\gamma$.) on the side of the body close to the front of the arch. The anterior two or three of these vertebers have a more or less strong flat inferior spine, sometimes of considerable length, and in the *Auks*, *Alca*, *Puffins*, *Grebes*, and *Penguins*, spreading out, at the tip, into a pair of branches, like a reversed T or V. In many *Divers*, and in many *Gallinaceous* Birds (F.), the inferior spines, though simple, are connected to each other, and form a deep keel. And in the latter, very commonly, several of these vertebers have their bodies, spinous (e.) and transverse processes (g.) connected with each other, forming a long, irregularly cylindrical piece, with three deep longitudinal plates, one vertical and two horizontal. Two or three of the hindmost vertebers have almost invariably their transverse processes connected with the hip-bones, which not unfrequently rise above their spinous processes, unite and conceal them, or, if not so high, are connected with them by lateral expansion of the tips of the spinous processes themselves.

In the *Hip-girdle* (G. H.) the bodies of all the vertebers are generally consolidated into a single long piece, compressed in front, depressed in the middle opposite the hip-joints, and again compressed towards the tail; in the adult animal the several pieces are distinguishable only by the jutting transverse processes, which are consolidated with the hip and haunch-bones. They include all those vertebers which in Beasts form the loins and the rump-bone; the former extend as far as the back of the hip-joints, and are separated from the latter, which are behind, by a pair of well-marked processes (g.), stretching directly outwards to the junction of the hip and haunch-bones at the back of the hip-joint. In some Birds, as in the *Common Fowl* (fig. 6. H.) and *Pigeons*, in the *Gallinaceous* Order, their broad, connected, transverse processes are very long, and separate the hip-bones widely apart; but in others, as the *Divers* (fig. 12. B.), they are short, and concealed by the hip-bones rising up, and becoming attached to the sides of the spinous processes, or to their tips, as in the *Emeu*, *Dromiceius Australis*, and *Nandu*, *Rhea Americana*: in the latter, however, the hinder spinous processes are unconnected with the hip-bones, but as the bodies of these vertebers pass over the united ischial tuberosities, they are consolidated together, so that the tail is movable only beyond. In the *Ostrich*, although the transverse processes are anchylosed to, and concealed by, the hip-bones rising to the level of the ridge of the spinous processes, yet all the latter are distinct.

The number of vertebers in the *Tail* (G. H.) varies from five to ten, but six, seven, or eight is the most usual number; some of the most anterior are generally anchylosed to the haunch-bones; and all, except the last, which has a peculiar form, and is largest, have the vertebral canal continued through their arches, beneath the superior spinous processes. Their bodies are more or less rounded laterally, and usually the last two or three have inferior spines, which in the *Rapacious* Order, as in the *Hawks*, *Falco*, &c., bifurcate; but in the *Short-winged Waders*, as the *Ostrich*, *Struthio camelus*, *Emeu*, *Nandu*, &c., they are deficient. The transverse processes are very distinct, incline backwards, outwards, and slightly downwards; their size and length vary considerably; in the *Gallinaceous* Order they are large; in the *Passerine* long, especially in the *Goat Sucker*, *Swift*, &c., but not very bulky; and in the *Bustards* they are of great length: on the contrary, in the *Grebes*, they are very short; also in the *Ostrich*, but deep, and a notch divides each into an upper and lower process: in the *Emeu* they are small; but in the *Nandu* neither spinous nor transverse processes exist, and the bones are irregularly cylindrical, tapering from the rump to the tip. The last tail verteber (H.‡) is distinguished by its greater size and length, which sometimes equals one-third of the whole length of the bony tail, as in the *Divers*, *Gannet*, &c., and in a few instances more than half, as in the *Peacock*, *Pavo cristatus*: in others it is very short, as in the *Ostrich* and *Emeu*, and in the *Nandu* is merely a conical stump. Its size depends on the superior spinous process, which rises like a ploughshare in all, except the *Web-footed*

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Zoology. Order, and a few others, in which it is low. In the *Peacock*, this process (fig. 15. e.) is of remarkable bulk, and at its top stretches forward, is connected with the spinous processes of the preceding two or three vertebers, and on each side also spreads out, and has a broad heart-shaped form. Its transverse processes (g.) are also of very great extent, producing a heart-shaped stage for the expansion of its large tail quills. So also in the *Woodpecker* (fig. 3. A. g.), they are very large and expanded to support the tail-quills, which form a prop, and assist the bird in climbing. In the *Gallinaceous* Birds, a slightly projecting ridge on each side alone indicates their existence; and in very many Birds they are scarcely perceptible. In the *Cormorant*, *Penguin*, *Aptenodytes demersa* (fig. 8.‡), and others, the last verteber has a lengthened trigonal form; but in the *Grebes* and *Divers*, it is compressed laterally and shaped like the point of a sword.

2. Of the Head.

The Head of Birds is transitional between Reptiles and Beasts, having, with the latter, the pieces of the skull immovably connected, and its cavity of considerable size; and, with the former, the pieces of the face movable on the skull and on each other in connexion with the motions of the jaws, and the articulation with the spine by a single condyle.

The peculiar classic characters of the Head are: 1. The early and perfect consolidation of the proper skull bones into one, so that it is difficult to define their exact boundaries, and impossible to separate them into distinct pieces when once connected; its resemblance in this respect to the skull of Cartilaginous Fishes has been noticed by Meckel: 2. The connexion of the tympanal portion of the temporal bone by a true joint with its squamous and mastoid pieces which form part of the skull: 3. The correspondent mobility of the palate and tympanal bones through the intervention of the pterygoid portions of the sphenoid, which motions affect the upper jaw, or mandible; and 4. The vertical motion of the face upon the frontal bone.

The Skull is compared in shape, though not aptly, by Cuvier to that of a pear: more or less vertical, and irregularly flat behind, it is arched transversely above, and has the deep cavities of the orbits indented in the fore and lateral parts, separated from each other only by a thin partition of bone or fibro-ligamentous tissue, or of both, and open beneath; the under or basilar surface of little extent, projecting in front a long ploughshare-like process, and having on each side pits, in part for the lodgment of the upper ends of the tympanal bones, and in part to form the cavities of the ear-drums.

In the Occipital Bone (fig. 6. J. K. 1.) the large hole ($\phi$.) for the entrance of the spinal marrow into the cavity of the Skull has at its lower edge a single little well-defined semi-globular condyle ($\chi$.) jutting backwards, with a more or less distinct pit on each side, and in front the basilar part ($\beta$.) of the bone, partially hidden by the underlapping of the sphenoid bone. The vertical or occipital part ($\nu$.), rising above the condyle, and including the occipital hole, is traversed by two curved ridges, the lower ($\mu$.) immediately over the hole, and the upper ($\nu$.) more strongly developed one far above it. In many Birds, a vertical ridge ($\xi$.), of greater or less breadth and prominence, extends from the upper to the middle of the lower ridge.

In front of the basilar occipital is the body or basilar part of the Sphenoid bone (J. K. L. 2.), commonly triangular, with its base behind, its sides ($\zeta$.) joining the petrous parts of the temporal bones at the bottom of the deep cavities of the ear-drums; and its apex or azygos process ($\epsilon$.) stretching far forward beneath and between the orbits. Upon the azygos process the palate bones are moved forwards and backwards by the pterygoid bones, and act upon the upper mandible; its lower edge therefore is smooth, and more or less sharp or rounded relatively to the degree of motion here performed: thus in the *Parrots* and *Maccaws*, and also in the *Cormorant*, it is very sharp; whilst in the Family of *Fowls* and that of *Ducks*, it is more rounded, and the very slight motion of their upper mandible is further indicated by a lengthened articular surface ($\zeta$) on each side of the process near its origin, for the inner anterior ends of the pterygoid bones, which are therefore restricted in their motions. To the upper edge of the azygos process is attached the vertical plate of the ethmoid bone, more or less throughout its whole length. From each front edge of the body ascend the orbitar plates ($\eta$.), which separate from each other above the azygos process, converge as they enter the back and under part of the orbit, forming generally, when the orbitar partition is imperfect, a large single hole ($\theta$.), through which the optic nerves pass, as in the *Divers*, *Cormorants*, *Herons*, &c., whilst, on the contrary, where the partition is perfect, as in the *Hawks*, *Owls*, *Fowls*, and *Ducks*, a narrow slip of bone divides it into two.

The distinct pterygoid portions of this bone belong especially to the motions of the upper jaw, and will be more conveniently considered in treating of the Face (See page 322)

The Temporal bones (L. 3,) placed above the sphenoid upon each side of the Skull, occupy the space between the occipital bone behind and the orbit in front. The Temporal bone of Birds is distinguished from that of Reptiles by its mastoid, squamous, and petrous portions being consolidated into a single piece; the former two composing the external face of the bone, and the latter projecting into the cavity of the skull, though partially seen through the great cavity of the ear-drum ($\omega$.), which is bounded above, behind, and beneath by the mastoid piece ($\iota$.) as it joins the occipital bone by its mastoid process ($\iota$.*), thin but much expanded, and very largely developed in the *Maccaw*, *Macroceros Ararauna* (fig. 4. A. $\iota$.*), and also in the *Cormorant*, *Carbo Cormoranus* (fig. 11. A. $\iota$.*). The hollow before and above the drum cavity is in the pit ($\kappa$.*) for the temporal muscle, the attachment of which above is shown by a curved line, in the *Rapacious* Birds: it is of great extent, and forms the largest part of the squamous portion ($\kappa$.); its lower hinder edge forms the upper anterior margin of the auditory passage, and in most Birds sends down a process ($\kappa$.**) which is certainly a lengthening of the articular eminence seen in Beasts leaving between itself and the pit a smooth surface, over which the temporal muscle plays: in some Birds, as the *Divers*, it is scarcely visible; in the *Hawks* it is rather larger; in the *Owls* it forms a small sharp, thin, but distinct process; but in the *Parrots* it is very large and distinct; in the *Common Fowl* it is very long, and in the *Cock of the Woods* still longer, very wide, and connected by its outer edge to the posterior orbitar process of the frontal bone, so as form a complete hole, through which the temporal muscle plays. This process forms also, as in Beasts, the front boundary of the transverse concave articular cavity ($\kappa$.†), for the condyle of the



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tympanal bone, which is separated behind from the drum by a thin process, also from the squamous piece, and especially distinct in the *Owls* (fig. 2. A. ε.††).

The Parietal bones (L. M. 4) form all the back part of the vault of the Skull, generally speaking above the temporal ridges. They commonly have a smooth and regular surface, but in some instances their junction in the mesial line is marked by a less or more distinct ridge, as in the *Divers* and *Cormorant* (fig. 11. A. λ.), &c.; and in the latter, at the junction of the ridge with the occipital bone, a long movable process (*) stretches backwards.

The Frontal bone (L. M. 5.) is the largest portion of the vault of the Skull, extending between the parietal bones and those of the Face. It is very broad behind, narrows in front according to the width of the base of the beak, and is divided by a wide gap into the two short, broad, nasal processes (σ.) within which are received the nasal and intermaxillary bones; on each side it is carved out to form the superciliary ridges (π.) or upper margins of the orbits. If the space between the orbits be wide, the forehead is either flat, as in the *Cormorant* and *Ducks*, or vaulted laterally, as in the *Parrots*; if narrow, it is usually slightly concave in the same direction, as in the *Hawks*, *Owls*, *Passerine*, and *Wading* Birds. In the *Divers*, *Mergansers*, and some others, a longitudinal ridge stretches forwards from opposite the middle of the forehead to its junction with the Face, produced by a deep groove which separates it on each side from the superciliary ridges, and following their curve, lodges certain glands. In some instances the forehead has a remarkably elevated crest, flattened laterally, as in the *Peafowl*, *Numida cristata* (fig. 22.†), and *Cassowary*; in others, as in the *King Duck*, just behind its junction with the Face, it rises in form of a pair of broad flat tubercles, rendering this nearly as wide as the hinder part of the bone. The lateral edges or superciliary ridges (π.) are generally sharp, and forming a more or less extensive curve, according to the size of the eyes, which are large, and requiring corresponding cavities in all Birds of great size in all the *Rapacious* Order. Behind, the superciliary ridge terminates in the long posterior orbitar process (ρ.),* which bounds the front of the temporal pit, and is, in the *Cock of the Woods*, united to the articular eminence: it is generally very distinct, and in the *Common Fowl* and *Cock of the Woods*, and in *Ducks*, it is very large, but small in the *Waders*. In front the ridge thickens, is either straight, as in the *Hawks*, *Common Fowl*, and others, or forms a second and smaller curve, as in the *Owls*, to give attachment to the lachrymal bone of Cuvier, Tiedemann, and Meckel. This is more probably, however, the anterior orbitar process of the frontal bone (ρ.†), remaining distinct, as in Reptiles. It consists of two plates, a horizontal one (ρ.†), somewhat quadrangular, which in some Birds, as the *Hawks*, juts outwards and backwards, leaving a gap between itself and the superciliary ridge, and in this Family has its tip lengthened by a little flat bone, rendering the front of the orbit very wide. In some other Birds it does not thus project, but continues the regular anterior margin of the orbit with little interruption, as in the *Common Fowl*. The other plate (ρ. †. †.) is nearly vertical, and, curving a little backwards, is sharp and thin in the *Fowl*, thin but wider in the *Hawks* (fig. 1. A. ρ. †. †.), and in some of these, as the *Sparrow Hawk*, descends so low as to touch the zygomatic process. But in the *Parrots* and *Woodcock* it is most developed: in the former it (fig. 4. A. ρ. †. †) first descends, then curves backwards and upwards, gradually thinning, and joins the posterior orbitar process, forming a complete bony margin to the orbit; in the latter it (fig. 13. ρ. †. †.) is comparatively much wider, and facing forwards as it descends, renders the front of the Skull as wide as its hind part. From the superciliary ridges a second or under table (σ. σ.*) of the bone separates, dips downwards and forwards at the posterior part to join the temporal and sphenoid bones, and form the orbitar plates or (σ.) back of the orbits; and downwards and inwards (σ.*) between the orbits to join the partition-plate of the ethmoid and separate the orbits; these two longitudinal edges are farther apart at the back of the orbits, but receiving between them the body of the ethmoid: in those Birds in which the ethmoid does not participate in the formation of the Skull, as the *Cormorant*, *Godwit*, &c., a wide gap is observed, or this may be divided into two, as in the *Herons*, by a slender vertical slip of bone, the rudiment of an ethmoidal (L. 6.) participation in forming the Skull.



The Ethmoid bone (L. 6.) consists of a body and vertical plate. The body (τ.) occupies the space between the orbitar plates of the frontal bone, and has a pair of holes, or a notch, which with the superjacent frontal bone forms a single hole, for the passage of the olfactory nerves from the Skull, as in the *Hawks* and *Common Fowl*; but sometimes the body is deficient, as in the *Cormorant*. From a vertical plate (τ.*) is continued forwards between the frontal intermaxillary and sphenoid bones, its upper edge grooved lengthwise, to complete with the frontal the canal in which the olfactory nerves extend to the nose. This partition-plate varies in thickness, is perfect, as in the *Common Fowl*, perforated with a hole near the body, as in the *Hawks*, *Crow*, &c., where the body is wholly or partially wanting, as in the *Cormorant*, *Heron*, &c. it is so largely deficient that there seems scarcely any bony partition between the orbits. Generally upon each side the front of this plate a flat plate (τ.†) juts out, forming the fore and under part of the orbit, and this seems to be the analogue of the Lachrymal bone; it is not equally distinct in all Birds, but it is well marked in the *Rapacious* Order, and in some of the *Waders*. In other instances, as in the *Crows*, *Parrots*, *Woodcock*, and *Merganser*, it is consolidated with the inside of the anterior frontal bone, and then forms the posterior bony boundary of the nostrils, which otherwise is only fibro-ligamentous. The *Ostrich* Family presents a remarkable peculiarity in the appearance of the Ethmoid bone upon the forehead. In all other Birds, the upper edge of its partition plate is not continued beyond the edge of the nasal gap of the frontal bone, the intermaxillary, therefore, articulates in most instances with the latter bone, by overlapping the middle of this edge, or by a hinge-like connection with both bones, as in the *Parrot* Family, both of which modes will be hereafter described. But in the *Ostrich* and others of its group, the front of the partition plate (fig. 7. A. σ.*) projects before the frontal edge, and, rising to the surface, interposes itself between the nasal bones (8. 8.) on the sides and the intermaxillary bone (7.) in front,

* Cuvier considers this to be part of the Sphenoid bone, but without very good reason, as it is certainly the analogue of the posterior frontal bone of Reptiles.

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by the latter of which it is partially overlapped, so that in these Birds the motions of the upper mandible are performed on this and not on the frontal bone.

The FACE includes the orbits, of which however the principal part formed by the bones of the skull has been already described, the nostrils and the jaws. Of these the latter are most largely developed, and afford a very important character in the ordinal divisions of the Class, and serves as a tool or instrument by which the Birds construct their nests, pierce or break to pieces hard substances in which their food is contained, or cut it in pieces as if with scissors to diminish its size, and render it convenient for swallowing.

The mechanism of the Upper Jaw has a remarkable resemblance to that of the Saurous Reptiles, but differs in the mobility of the tympanal bone upon the squamous part of the temporal and in its connection by other bones with the upper jaw and intermaxillary bones, which consequently follow its motions, the point of movement being at the junction of the face with the frontal and ethmoid bones. The Upper Jaw or Mandible consists of two portions, first, the part to be moved, or *Mandible* properly so called, including the single intermaxillary, the pairs of nasal-superior maxillary, and turbinated bones, and the ploughshare bone, all of which, excepting in the *Gallinaceous* Order, are more or less perfectly consolidated into one, and invested in a horny covering; secondly, the levers or parts by which the former is to be moved, consisting of an inferior inner pair, viz., the palate and pterygoid bones, and an outer pair, viz., the malar and zygomatic bones, the front ends of both pairs being affixed to the mandible as the hind extremities are to the tympanal bone.

The Intermaxillary bone (K. L. M. 7.), the largest piece of the mandible, is of very considerable size, forms the point of the beak (a), widens behind, and divides into three branches, the lower two (b. b.) forming the margins of the mandible, and joining the slender malar bones behind; the upper single one (c.), generally slender, ascends to the gap of the frontal, which it overlaps in all Birds, except in the Family of *Ostriches*, but in these it overlaps the front of the top of the ethmoid bone; it forms the ridge of the beak, and by its separation from the lower bounds the anterior half of the nostrils. Its under surface (d.) is concave in most instances from side to side, the edges descending below it, and in the *Hawks* these have always a more or less acute triangular process or tooth, and the same process, though of smaller size, exists in most of the *Dentirostral* Birds, as the *Shrikes* especially. The length, width, and shape of the Intermaxillary bone is very different, and upon it almost entirely depends the size and form of the beak of Birds.

The Nose bones (L. M. 8.) are situated one on each side of the upper or nasal process of the intermaxillary, and with it in most Birds, rest behind upon the top of the ethmoid, having the anterior orbitar process of the frontal bone without; in front each divides, as is especially well seen in the *Gallinaceous* Birds, into two branches (d. d.), received within the branches of the intermaxillary, with an intermediate gap bounding the hinder part of the nostril. The Nasal, by its upper end (e.) and intermaxillary have generally a bony union with the ethmoid and frontal bones, and upon their thinness and pliability depends the mobility of the upper mandible; but in the *Parrots* and *Maccaws*, no such bony union exists, and their connection is by a perfect hinge, the ethmoid forming a long central groove (fig. 4. C. e.), hollow from above downwards, and the frontal bone on each side having a long and rounded transverse ridge, upon which (*p.* ††) the corresponding convexity of the intermaxillary and concavities of the Nose-bones are received, and thus a perfect joint is formed. In the *Cormorant*, *Gannet*, and others, an indication of this mode of connection is observable, but in them the true joint exists only between the intermaxillary and ethmoid, the frontal and nasal being united by bone.

The Upper Jaw bones (L. M. 9.) are as remarkably small as the intermaxillary is large. Placed between the furkings of the horizontal processes of the latter bone, and the lower processes of the nasal bones, they stretch inwards their palatine processes (f.) to assist in forming the bony palate and floor of the nostrils. Sometimes these processes are connected together, and to the ascending intermaxillary process by ligamento-cartilage, which forms a partition between the nostrils, as in the *Common Fowl*. But in other instances, as in the *Hawks* and *Owls*, their inner edges rise to the intermaxillary, and form a bony partition in the nose. Behind, at their inner corner (g.), they join the anterior extremities of the palatine bones, and from their outer each sends back a thin, rather long process (h.), to underlap the corresponding malar bone. In the *Cock of the Woods* the Jaw-bone is Z-shaped, but with the obliquity of its stem reversed; its palatine process is very narrow, and sends inwards from near its posterior end a thin horizontal branch towards its fellows. In the *Parrots* and *Maccaws* the process joining the malar bone is deficient, and in its stead is a concavity (fig. 4. D. h.) upon which the rounded extremity of that bone plays.

The Mandible thus formed and connected to the Skull either by overlapping or by a hinge joint, in most instances is capable of more or less vertical motion. The apparatus by which this motion is effected consists of the movable tympanal pieces of the temporal bones which swing forwards and backwards, projecting or retracting the bony levers interposed between them and the mandible. In Fishes the tympanal bone or tympanal portion of the temporal moves upon that bone, backwards and forwards, and from side to side, and in all Ophidian Reptiles the same motions are permitted, upon its mastoid pieces; but in the other Orders of that Class, the tympanal bone is motionless, and connected with the squamous, as well as the mastoid piece of the temporal drum cavity, more or less like the head of a shepherd's crook. In Birds, however, the bone is always distinct, has always the same general characteristic form and connections, although, from peculiar causes, the mandible may be immovably connected with the Skull, and therefore the general purpose of the Tympanal bone in such instances not carried out.

The Tympanal bone (K. L. M. 3.*) is situated in front of the ear-drum, its upper end (j.) lodged in the articular cavity of the squamous piece of the temporal; its lower end (k.) connected with the articular surface of the lower jaw; its outer surface (l.) with the slender malar bone, of which at first sight it seems to be the enlarged hinder extremity, and its inner (m.) with the short pterygoid bone. Anatomists have considered it to have a square form, and have therefore called it the Square or Quadrate bone; this name it perhaps more pro-

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perly deserves in the *Parrots* and *Ducks* than in any other Birds, but even in these the resemblance is not very close. It is rather of an irregularly triangular figure with its truncated apex, or articular head, above convex from before backwards, but narrower in this direction than from side to side, as is well seen in the *Hawks* and *Parrots*, and other strong-beaked Birds; indeed in the two former it is so wide that it forms a condyle (j.*) with two rounded articular surfaces separated by an intermediate depression. Below the head the middle of the bone is flattened on the sides, with its inner edge inclined obliquely forwards, from which the orbitar process (n.), lengthy, flattened, more or less pointed, stretches inwards and upwards towards the bottom of the orbit; sometimes it spreads and seems to rest against the orbitar plate of the sphenoid bone, as in the *Storks*, but more commonly it projects freely. The lower end of the bone is of considerable size, and varies in form; it has generally two rounded articular surfaces (k.*) separated by a concavity (k.), of which the outer is the largest in some Birds, as the *Hawks* and *Common Fowl*, whilst, on the contrary, the inner is largest as in the *Cormorant*, and in others, as the *Stork*, both are of nearly equal size. In some Birds, as in the *Crows*, *Cranes*, &c., a third little surface exists behind the intermediate hollow, which however is merely the inward lengthening of the outer articular process divided by a second depression. In the *Parrots* and *Maccaws*, in which there is considerable motion forwards and backwards of the lower jaw the lower end of the bone is much flattened laterally, and has but a single articular surface (fig. 4. A. k.*) which is convex laterally, and forming a large curve from behind forwards. In front of the inner condyle is a slightly rounded surface (m.*) for the reception of the pterygoid bone, but in the *Parrots* and *Maccaws* it is on the front of the single thin condyle, and very distinct. The outside of the outer condyle is hollowed into a little cup (l.*) for the reception of the inner hinder end of the malar bone; and when the condyle is divided into two, the cup is sometimes on the anterior part of the condyle, as in the *Storks*, sometimes on the posterior, as in the *Ducks*. In the *Gallinaceous* Birds the cup is less deep, but in the *Parrots* and *Maccaws* (l.*) is supported on a little eminence in the centre of the bone.

The Pterygoid bones (K. L. 2.*) or pieces of the Sphenoid are of a trigonal shape, varying in length, and passing from the inner condyles of the tympanal bones forwards and inwards to the azygos process of the sphenoid, where they abut against the hinder ends of the palate bones; both extremities (o. o.*) are cup-shaped, and the edges are generally sharp; sometimes they merely lie against the sphenoid at their junction with the palate bones, as in the *Hawks*; at other times their inner edge has a flat, articular surface (p.) corresponding to one on the side of the azygos process of the sphenoid, which may be close to their junction with the palate bones, as in the *Common Fowl*, or a little behind it as in the *Ducks*, or still farther back as in the *Owls*. In the *Parrots* and *Maccaws* (fig. 4. A. B. o. o.*) the Pterygoid bones are slender, rounded, and very long, their hinder end concave, and their fore extremity wide and convex.

The Palate bones (K. L. 10) placed in front of the pterygoid bones vary in form in different Birds; sometimes, as in the *Crows*, their hinder part is nearly square and arched laterally, the posterior inner angle (q.) connected with the anterior extremity of the pterygoid, and the inner edge (q.*) with its fellow, their junction forming a groove, which plays on the under edge of the azygos process of the sphenoid; whilst the fore and outer angle (q.†) projects a thin rounded process which terminates beneath the palatine process of the upper jaw-bone; a narrow longitudinal space is thus left between these thin processes, separated by a cartilaginous partition, and these are the hinder openings of the nostrils. In those Birds which have the mouth, or rather throat, wide, the Palate bones are wider and horizontal; in others, they are deep as in the *Ducks*. But in the *Parrots* and *Maccaws* (fig. 4. B. q.), in which they are nearly vertical, they are very deep, and stretch far behind and below the junction of the bone with the pterygoids; and their anterior extremities (C. q.†) are each furnished with a wide convex articular surface, received into corresponding sockets at the back of the upper jaw bones (D. h.); generally the two Palate bones are distinct from each, but sometimes they are united into one behind the nasal apertures, as in the *Cormorant* (fig. 11. B. q.).

The Pterygoid and Palate bones together form the inner pair of levers, connecting the tympanal bones with the mandible; and the connection of the two bones on each side of the sphenoid at a very open angle would not at first seem to be the most advantageous for propagating the motion of the tympanals to the mandible. This however is not the sole use of the pterygoid bones, a very important function of which is to serve as strets to the tympanals, and prevent their being drawn inward by the contraction of the throat muscles in swallowing; and it is for this reason that the junction of the pterygoid and palatine is angular instead of straight.

The outer pair of levers are much more simple, and their shape more uniform, their principal difference being in length, and generally, though not always, they are longer in short-beaked Birds than in those which have the bill long; but their length is generally correspondent to that of the orbitar cavity, dependent on the more or less vertical position of the tympanal bone.

The Malar bones (K. L. M. 11.) of which these external levers consist, are lengthy, rounded, and elastic. Their hinder part (r.), which seems correspondent to the zygomatic process of the temporal of Beasts, is more or less flattened laterally, and has upon its inside a little jutting conical process (r.*) received unto the cup of the tympanal bone, upon which it plays; the front of the bone, flattened vertically, is pointed (r.†), and generally overlaps the hind process of the upper jaw-bone, but in the *Parrots* and *Maccaws* it terminates in a wide convex articular surface (fig. 4. C. r.†), received into a corresponding cavity of the back of the upper jaw-bone.

As to the Nostrils, their size and form vary considerably, and generally they are large and oval, although in some instances, as in the true *Hawks* and *Vultures*, the oval space is filled with bone, excepting a comparatively small round aperture. In many Birds, as the *Cranes*, *Herons*, *Divers*, *Gulls*, *Puffins*, &c., the nostril is a simple long slit between the intermaxillary and nose-bone; in others, as the *Spoonbill* and *Cranes*, the slit is short; in the *Parrots* and *Maccaws* it is round, without any indication of an oval aperture; in the *Pelicans*, the aperture is still smaller, and in the *Gannet* it is not sufficiently large to admit a small pin. The space

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between the nostrils and the back of the mandible, of which the walls are formed by the nasal and intermaxillary bones, is filled up with bony convolutions, which may be considered to be the Turbinated bones (fig. 1. 2. A. B. a.); these in the *Rapacious* Birds are very large and complicated, and in the *Owls* project behind the mandible; but, on the contrary, in the *Gallinaceous* Birds, no such convolutions esist. In the *Awk* (fig. 23.) the Turbinated bones (s.) stretch back like a pair of little flat loops.

The Ploughshare bone (K. 12.) is a small single bone attached in front of the junction of the hinder extremities of the palate booes, and running forwards towards the palate, divides the posterior nasal aperture into two slits. It varies considerably in size, is small in the *Rapacious* and *Gallinaceous* (K. t.) Birds, but large in the *Web-footed* Order, of which in the *Divers* it is very long and sharp, and in the *Ducks* (fig. 8. t.) very deep. In some of the *Waders*, as the *Stork*, (fig. 24. t.) it consists of two long, thin, and nearly parallel triangular plates, joining in front by their tips, by their hinder outer edges with the palate bones, and above forming a groove which receives the lower point of the partition-plate of the ethmoid. In the *Parrots* and *Maccaws* the bone does not seem to exist.

The Lower Jaw (M. 13.) extends from beneath the tympanal bone, sometimes to the very tip of the intermaxillary, in which case both mandibles are of equal length; but in the *Rapacious* Order (fig. 1. 13.), and in the *Parrot-like Climbers* (fig. 4. 13.), is considerably shorter, received within it, and different in the form of its anterior extremity; in the *Lamellirostrous Web-footed* Birds, as the *Swans*, *Geese*, &c., it is also shorter, but has the same general form of tip; in the *Passerine* Order, and also in the *Gallinaceous* Birds, it is nearly or quite as long as the upper mandible; and in a large proportion of the *Waders* and *Web-footed* Birds it is of equal length and bulk in front as the intermaxillary. It consists of two branches (u. u.) united in front (*) at a more or less acute angle, sometimes, however, as in the *Rapacious* Birds, the union is rather rounded as in the *Vultures*, and also in the *Family* of *Parrots* among the *Climbers* this is especially so; in both the extremity is not pointed, but truncated, and the front is scooped out transversely. The depth of the braoches varies considerably, they are shallowest in the *Goatsuckers* and *Swift*, and deepest in the *Parrots* and *Maccaws*; in the *Rapacious*, *Passerine* and *Gallinaceous* Birds they are generally shallow. Each branch may be divided, in some Birds only when young, into several pieces correspondent with those of Reptiles, and in many instances a large gap exists betwean the upper and lower edge. The hinder extremities (††) of the Jaw are generally espanded laterally to form the articular surfaces (r. r.) for the condyles of the tympanal bone, and each is usually divided into twn cavities separated by a little ridge; on the inner side of the articulation, a rather strong process (r.*) rises upwards, which prevents lateral motion of the Jaw on the tympanal bones; but in the *Parrots* and *Maccaws*, in which the articular surface is only a long chase from before backwards, this motion is still further precluded by the great depth of the bone on the outside (r. †.) of the joint surface. The analogue of the coronoid process (χ.) is scarcely more than a slight elevation of the upper edge of the bone in front of the articulation. In some Birds, as in the *Parrots*, *Maccaws*, in many of the *Waders*, and also in *Ducks*, the hinder angles of the jaw (ω.) are of considerable sise, but in the *Rapacious* and *Passerine* Order generally this process is but slight.



3. Of the Chest.

The cunformation of the Chest of Birds is specially to provide a large surface for the attachment of the muscles moving the wings, and also (as nearly as may be) a solid support upon which the latter may be moved. The vertebers of the back already described form the upper hinder part of the Chest, of which the sides are composed of the ribs and the front by the breast-bone.

The Ribs consist of seven or eight pairs, and never exceed eleven; all connected with the bodies and transverse processes of the vertebers upon which they swing backwards and forwards. Of these two or three pairs in front, free and unconnected with the breast-bone, are called *false* Ribs, whilst all the others, excepting occasionally the last pair, are united with that bone by the intervention of short bony pieces, and therefore called *true* Ribs. Each Rib (fig. 6. N. 1.) is a segment of a half oval, its short axis horizontal, and its long one vertical; the upper end is flattened from before backwards, and its rounded extremity, or head (a.), attached to a little cavity on the body of the corresponding verteber; in bending down to form the long body, a little process, called the tubercle (b.) is produced, which rests against the transverse process of the verteber. From the tubercle downwards, the Rib, flattened from within to without, is externally smooth, but internally is ridged more or less, and its lower extremity has its tip (c.) hollowed out. From the hinder edge of each Rib, except the last pair near its middle, a broad flat process (d.) stretches backwards and upwards over the following Rib, and thus the whole set being overlapped, no Rib can move without the participation of all. The connection of the true Ribs with the breast-bone is by a corresponding number of little bones (e.), stretched between them obliquely from behind forwards, forming open angles, which, as these bony pieces, lengthened from before to behind, are more acute behind than in front: the upper ends are flattened from within outwards, as are their corresponding Ribs, but the lower ends compressed from before to behind, and expanded, have each a corresponding cavity, by which it rests upon a ridge on the side of the breast-bone; but the last piece is not unfrequently attached to that preceding it, instead of to the breast-bone. The false Ribs (N. 2.) have the same general form, but their lower end, free among the muscles, and without bony connection, is tapering and sharp-pointed. The first Rib is shortest, sometimes so very short as to seem scarcely more than a movable section of the tip of the transverse process, somewhat similar to the loose transverse processes of the *Crocodile* Family. In Birds of more powerful flight, the Ribs are wider, shorter, and more curved, as in the *Hawks* and other *Diurnal Rapacious* Birds, whilst in the heavy fliers, as the Family of *Divers*, especially the *Puffins* and *Auks*, they are more slender, longer, and less curved; exceptions to the latter rule, however, occur in the short wide ribs of the *Gallinaceous* Order.

The Breast-bone (fig. 5. O. 1.), as a large bony shield, covers not only the front of the chest, but also more or less of the belly, extending to and sometimes even behind the thighs. Generally of a lengthened quadrangular form, its upper hinder surface more or less con-

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cave, lengthwise, and from side to side, and the under fore surface correspondently convex, is divided longitudinally by a remarkable vertical mesial keel or sternal crest (e.). The front edge (a. a.) of the bone has in the middle a projecting spinous process (a.*), single and of small size in the *Hawks*, but large and compressed in *Gallinaceous* Birds, and sometimes forked as in the *Crow* (fig. 27. a.*); it is the analogue of the handle process of the Breast-bone of *Lizard-like* Reptiles. From each side of this process the edge stretches more or less obliquely backwards and outwards, to terminate in the anterior angles or lateral processes (a. a.), which in the *Common Fowl* and others are of considerable length. The side edges (s. h.) are thicker than any other part, and each has a number of transverse ridges (c. c.) separated by depressions, wider before than behind, upon which are received the sternal portions of the ribs, and, except in the *Wading* and some of the *Web-footed* Birds, rarely existing beyond the middle, whence the edge gradually thins towards the hind part of the bone. The posterior edge (h. b.) is either square, as in the *Hawks*, rounded, as in the *Cranes* and *Storks*, or cut off obliquely at its posterior angles, as in the *Common Fowl*: it is either perfect, as in the *Diurnal Rapacious* Birds (fig. 1. C. h. h.), in which generally a small oval aperture (d.) exists in front of each posterior angle, though in some, as the *Sea Eagles* and *Buzzards* (fig. 21. h. b.), even this is deficient; or, as is common to most other Birds, a notch (d.) on the inside of each angle forms a process, called the posterior lateral; sometimes a second notch (d.*) exists on each side nearer the crest, and a second or inner posterior process (b.*) is then produced, which is especially distinct in the whole *Gallinaceous* Order, and also in the *Owls*; but in many *Wading* Birds it is indicated by a single notch in the middle of the posterior edge. The width of the bone varies considerably in the different Orders; in the *Owls* (fig. 2. C.) it is nearly as broad as its length, which however is not great; in the *Diurnal Rapacious* Birds, as the *Hawks*, (fig. 1, C. fig. 21.) it is wide in comparison to its length; narrower in the *Gallinaceous* Order, and still more narrow and long in the *Puffins* and *Awks* (fig. 23. B.) and other Divers; but its general extent is largest of all in the *Lamellirostrous* Family, as the *Swans* and *Ducks* (fig. 9.). The depth and size of the holes or clefts at the posterior edge are important, as diminishing the solidity of the attachment of the breast muscles, and consequently their efficient action: thus in the *Sea Eagles* the whole extent of the bone is perfect, in the *Hawks* the pair of holes near the hinder edges, which in the *Owls* and the *Passerine* Birds become converted into clefts, indicate less power; but in the *Gallinaceous* Birds the actual lateral bony surface is very small, the inner cleft extending widely up as far as the front of the base of the keel, and the outer one forming a large triangular space by the outer posterior lateral process stretching outwards nearly at right angles with the keel, and overlapping the sternal part of the hinder ribs. The most remarkable character of the Breast-bone is its sternal crest or keel (e.), which varies considerably in extent and depth in different Orders: in the strong-flying Birds, as the *Hawks*, its lower edge is convex, so that it is deepest about its middle, in the *Divers* and *Ducks* it is straight, commencing at or near the middle of the hinder edge, the crest stretching forwards sometimes to the root of the spinous process, and sometimes beyond it as in the *Divers*, *Cormorant*, *Gannet*, &c., in which it assumes a sharp angular form: on the contrary, in other instances it does not reach the spine, and in the *Gallinaceous* Birds the front of the crest is cut off obliquely backwards, so that its most prominent part, instead of being at the fore part, is opposite the middle of the Breast-bone, as in the *Common Fowl*, and especially in the *Turkey* (fig. 14. e.). The thickness of the keel or crest is generally not great, excepting its edge, which is rather thicker than elsewhere, and in the *Wading* Birds thicker than in others, but one of these, the *Sirus Crane*, and also the *Swan* (fig. 20. e.), are remarkable for its great thickness, dependent on its being composed of two plates of bone, between which is left a large space containing the convolutions of the long Wind-pipe for which these Birds are remarkable. In the *Ostrich* Family, which do not fly, and of which the wings are rudimental, the Breast-bone (fig. 7. B.) is short and square, or pentagonal, without any keel or crest, of which the only indication is the slight mesial ridge in the *Nandu*, *Rhea Americana* (fig. 16. A. e.), which has the largest wings of its group. The Breast-bone of the *Apteryx Australis* (fig. 17. A.) however is the most remarkable of the whole Class, and of it Owen observes, "the *sternum*, the main characteristic of the skeleton of the bird, is reduced to its lowest grade of development in the *Apteryx*. In its small size, and in the total absence of a keel, it resembles that of the Struthious Birds, but differs in the presence of two subcircular perforations on each side of the middle line, in the wide anterior emarginations, and in the much greater extent of the two posterior fissures."* No less important in reference to the powers of flight than the size of the crest are the articular cavities (f. f.) for the coracoid bones: these are lengthy grooves parallel to and behind the edge on each side of the front of the crest, and in accordance with their less or greater obliquity to the crest are the coracoid bones stretched more or less forwards or outwards, in the former case bringing the wing nearer the chest, diminishing the freedom of its motions and the size and action of its depressing muscles, and in the latter the reverse, consequently the more upright the coracoid bones are the less suitable for flight are the wings, as in the *Common Fowl*, and the more they incline outwards the more free and powerful are the motions of the wings, as in the *Swifts*, *Humming Birds*, and *Hawks*.

4. Of the Locomotive Organs.

The support of the trunk of Birds, and its motions on the ground, are intrusted to the hind limbs or legs only, but in the air these offices are performed by the fore limbs or wings, which have a peculiar arrangement for that purpose, in consonance with which is the construction of the whole skeleton; and the same general type is still preserved even in those few Birds which are incapable of flight.

A. *Of the Wings.*

The Wings of Birds have a close analogy with Reptiles in the great development of the collar and coracoid bones and their strong and immovable connection with the broad breast-bone. The composition of the wrist and hand is however peculiar to the Class.

The *Shoulder-Girdle* in all Birds, except the *Ostrich*, consists of three bones, the blade-bone, the cora-

* See his paper *On the Anatomy of the Southern Apteryx*, in Zool. Trans. vol. ii.

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coid bone, and the collar-bone, the latter of which, with but very few exceptions, is anchylosed with its fellow, and hence commonly known from their shape as the fork-bone.

The Blade-bone (fig. 6. P. II.) rests upon the ribs a little below and nearly parallel with the spine; it is scimitar-shaped, more or less curved, with the edge (1.) upwards, the point (2.) backwards, and the side against the ribs. Its anterior extremity divides into two processes, the upper anterior acromial or furcular process (3.), by its extremity, joins the collar-bone; the lower, outer, and posterior or articular (4.), hollowed from before backwards and from above downwards, assists in forming the Shoulder-socket. Between these two processes to their inner side, and upon the fore and under part of the bone, is a concavity (5.) for the fibro-ligamentous junction of the coracoid bone.

The Coracoid-bone (O. P. III.) joins the last described at an angle opening backwards, and descends inwards and backwards to articulate on the breast-bone. Its upper anterior extremity, flattened from within outwards, terminates in two processes, of which the anterior under largest one (7.) has, upon its inner side, an articular surface for the collar-bone; the other (8.) projects inwards, and has upon its upper part an articular surface for the blade-bone: between these processes is a deep notch (*) over which the tendons of the muscles raising the wing play. Upon the outer and upper surface is a large articular surface (9.), concave from before backwards, and from within outwards, forming the largest part of the Shoulder-socket. The middle of the bone marked by more or less distinct ridges indicating the attachment of muscles, gradually spreads laterally as it descends, so that the lower end is flattened from above downwards, and terminates in a wide articular surface (10.), convex from above downwards, and received into the corresponding cavity on the front of the breast-bone.

The Collar-bones, or, describing them (as they really are) as a single-bone, the Fork-bone (O. IV.) is V or half-oval shaped: it is placed before the breast and below the coracoid bones, with its angle or base (13.) formed by the union of its branches or pieces (14. 14.), which is indicated by a distinct compressed process or little stud (13.*), called the sternal, in front of the breast-bone, and the branches themselves stretching forwards and outwards to the inside of the anterior ends of the coracoid, with which they are joined by ligament, rise a little forwards and upwards, each terminating in a point attached to the acromial process of the blade-bone, and thus a distinct aperture is formed between the three bones. In the *Diurnal Rapacious* Birds, as the *Hawks* (fig 1. C. IV.), *Eagles*, and *Vultures*, the Fork-bone is halfoval; the junction of its two branches is indicated by a very small stud or sternal process (13.*) each, with its outer edge everted, curves considerably forward, much compressed and deepening towards its union with the coracoid and blade-bones. In the *Nocturnal Rapacious* Birds, as the *Owls* (fig. 2. C. IV.). the branches of the Fork-bone are very slender and slightly S-shaped, being concave forwards below and convex above, and expanded only at the Shoulder. In the *Passerine* Birds generally the branches of the Fork-bone are longer and less expanded and curve regularly forward; their sternal process is also more or less distinct and compressed. In the *Swifts* (fig. 10. C. 14. 14.) the branches are widely separate, and in miniature their Fork-bone resembles that of the *Hawks*. The *Creepers* are remarkable for the extreme tenuity of their branches, so also the *Woodpeckers* (fig. 3. A. IV.), and the greater number of the *Parrot* Family (fig. 4. F. IV.), but the general form of the bone still remains the same. Among the *Parrakeets* and the *Ground Parrots* some occur which are remarkably distinguished by the entire absence of the Fork-bone, of which not the slightest trace exists: a good example of this peculiarity is the *Love Bird*, *Psittacula* (fig. 5. A.). In most of the *Web-footed* (fig. 9. B. IV.), and *Wading* Birds the branches are slender, their sternal process is large, and in some, as the *Cormorant*, *Gannet*, *Cape Petrel*, and *Albatross*, articulates with the crest of the breast-bone, whilst in others, as the *Adjutant Bird*, *Ardea Algala* (fig. 19. I. IV.), *Cyrus Crane*, *Grus Antigone*, the two bones are anchylosed at this point. In the whole *Gallinaceous* Order the Fork-bone is nearly if not completely V-shaped; its branches joining at an acute angle, whence springs the large compressed sternal process; the anterior plane of the bone is also slightly curved; but among these Birds the *Turkey* (fig. 14. IV.) has the most perfect V shape, and its straight branches lie so flat upon the front of the coracoid bones that the Fork-bone is often overlooked.

The Shoulder of the *Ostrich-like* Birds differs remarkably from the rest of the Class, and has a close resemblance to the Batrachian Reptiles in the blade and coracoid bones consisting only of a single undivided piece. In all, the Blade-bone is long, flat, and horizontal instead of vertical, as in Reptiles, upon the ribs; it curves slightly downwards and expands vertically in front into a broad flattened acromion, at the lower and under part of which is a semilunar notch, the Shoulder socket, its fore and under part formed by the Coracoid bone, which descends forwards, widening to the articular cavity on the front of the breast-bone. In the *Nandu* (fig. 16. A. III.), from the upper and fore part of the Coracoid piece a little flat projection (IV.) marks the rudimental Collar-bone, but in the *Ostrich* (fig. 7. B. IV.) this becomes a very broad process which passes down, joins with the expanded inner point of the base of the coracoid portion, having left an oval aperture between them, and is with it actually received into the sternal joint, but does not join with its fellow of the opposite side; it is doubtless the Collar-bone. In the *Emeu* the Collar-bone, distinct, short, curved, and flattened, lies upon the flattened acromial process. In the *Apteryx* (fig. 17. A. III.) the blade and coracoid bones are anchylosed, and a small perforation anterior to the articular surface, for the humerus indicates the separation between the coracoid and rudimental clavicle, of which there is otherwise not the least trace.*

The *Wings*, generally so called, include the upper and fore-arms, and the hands. Their connection with the articular socket of the shoulder is effected by the head or fore extremity of the upper arm-bone. The Wing, at rest, is folded upon the side of the chest, its first two portions, the upper and fore-arm, being nearly parallel to but below the plane of the spine, with the elbow behind and the wrist in front, and from the latter, the third portion or hand stretches downwards and backwards, forming an angle with the fore-arm. In consequence of this arrangement the hand swings forwards and backwards nearly in a vertical plane, as the wing is

* See Owen, *loc. cit.*



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simply opened or closed, whilst the fore-arm moves from the upper arm at the elbow-joint in a horizontal plane backwards and forwards as it is outspread or shut up, and the upper arm forwards and backwards upon the shoulder-socket in the same motions. But in forward flight the wings move forwards and backwards upon the shoulder-socket like a pair of oars, whilst in towering or vertical upward flight they swing upwards and downwards.

The Upper Arm-bone (Q. R. v.) is the largest, though not always the longest, piece of the Wing. In shape it resembles an italic ∽ laid horizontally, the anterior extremity curving inwards and the posterior outwards. Its middle or body (17.) is tolerably cylindrical and smooth. The anterior extremity (18), curving inwards, expands vertically, and especially downwards, into the large tubercle (19.), on the inside of which is a large aperture (19.*) for the passage of the air-duct into the shaft of the bone; the upper anterior edge expands outwards into a broad lip (20.) for the attachment of the breast muscle, and its fore extremity is sometimes developed into a tubercle (21.), but of smaller size than the former. Between the tubercles the articular surface or head (18.) faces forwards and inwards, of a compressed vertical ovaloid form, and separated from the lower tubercle by a deep notch. The posterior extremity (22.) also expands vertically, is less deep but more cylindrical than the anterior, and is bounded above by a small (23.) and below by a large condyle (23.*), between which are two articular surfaces or pulleys, facing outwards and rather backwards; the lower pulley (22.) for the cubit is nearly hemispherical, with a pit (22.*) behind for the olechranon, and under-cut in front for the articular lip of that bone; the upper pulley (24.) for the spoke-bone is of much greater extent, and, like the segment of a wheel-felly, stretches obliquely downwards before the former; in consequence of which obliquity, when the fore is expanded upon the upper arm, it does not move in the same horizontal plane, but is thrown upwards, and therefore in extension the upper and fore arm together form an open angle instead of being straight. The principal difference in the Upper Arm-bone of Birds is its length; in some of the *Wading* and *Web-footed* Orders it reaches to the tail, and even beyond it: in the *Divers* it stretches rather behind the hip-joint, but in the *Accipitrine* Order, only reaches it: in the *Passerine* and *Climbing* Birds, only to the crest of the hip-bone: in the *Gallinaceous* and most of the *Wading* and *Web-footed* Orders it is still shorter; but shortest in the *Swifts* and *Humming Birds*. On the proportionate length, however, of the Upper-Arm to the fore-arm depends the power and speed of flight: thus in the quick-flying Birds, as the *Hawks*, and especially the *Swifts*, the Upper is much shorter than the fore arm, whilst in the heavy fliers, as the whole *Gallinaceous* and *Web-footed* Orders, it is longer than the fore-arm, and among the *Ostrich* Family is either three or four times as long, as in the *Ostrich* and *Nandu*, or of equal length with it, as in the *Cassowary* and *Emeu*; but in these last, both upper and fore arm are remarkably short. Difference of form is but little; the most striking is that of the *Swifts* (fig. 10. v.), in which the Upper Arm-bone is flattened from without inwards, and especially expanded at the anterior extremity, the lower edge (19.) close to the air-hole being developed into a large process, and the hinder end of the pectoral ridge or lip (20.) elevated into a stout triangular process curving forwards; the hinder end is also very broad, and the pulley for the spoke-bone is separated distinctly from that for the cubit. In the *Humming Birds* the same pectoral process exists, though comparatively small, but the whole bone is wider than in the *Swifts*. In the *Puffins* and *Awks* (fig. 23. C. v.), the Upper Arm-bone, and indeed all the bones of the Wing, are remarkably compressed from before backwards; this is especially so in the *Penguins* (fig. 8. v.), of which the whole arrangement of the upper extremity is to the production of a fin rather than of a wing, its several portions being almost motionless upon each other, and when covered by their soft parts, presenting a broad sickle-like limb, which depends nearly vertically from the shoulder, the Upper Arm-bone hanging from it in a state of pronation, so that the surface which in other Birds is external is in this anterior. The shaft of the bone is flattened from within outwards; the upper articular surface (17.) faces backwards, and the tubercle is scarcely discernible: the lower end, its breadth being insufficient to allow the articular surfaces for the fore-arm, being on the same horizontal plane (24.), has that for the spoke-bone above that (22.) for the cubit, and both nearly flat and connected, have the shape of a vertical section of a common bean with the convexity outwards. Behind them and on the inside is a little narrow pulley (†.) with sharp edges, separated from the outer surface of the bone, which is not continued so low by a deep cleft; upon this pulley and hollow the movable olechranon rests. Among the *Ostrich*-like Birds, the *Ostrich* (fig. 7. v.) and *Nandu* have the Upper Arm of the usual form, but of slender proportions, and with little developed processes; but in the *Cassowary* and *Emeu* (fig. 18. A. v.) it is extremely short, in the latter not exceeding four inches, of a flattened cylindrical form, more flattened and expanded inwards at the anterior extremity, which has a wide articular surface (17.) convex from before backwards, but with scarcely any appearance of tubercle or pectoral ridge. Its hinder end (22.) is still less expanded, is slightly convex, but not inclined forwards, so that it does not admit flexion of the fore-arm upon it.

The *Fore-Arm* consists of two bones, the cubit and spoke-bone, of which the latter is always in a state of semipronation.

The Cubit (Q. R. vi.) curves slightly inwards, and has its shaft or middle part (27.) tolerably cylindroid: the posterior end or head (28.) expanded vertically, and of a somewhat trigonal form, has two concave articular surfaces, the lower (28.) cup-shaped, facing backwards and inwards for the hemispherical articular pulley of the upper arm, and bounded behind by the little projecting olechranon (*), the upper (29.) semilunar and inclined obliquely backwards and inwards, with its upper edge hollowed for the head of the spoke-bone which rotates in it, and with it perfects the socket for the upper oblique pulley of the upper arm-bone. The anterior extremity or base (30.) expanded laterally and from above downwards, has a large articular surface (30.) for the two wrist-bones and the great palm-bone, facing inwards and downwards, convex vertically and concave from side to side, with an external semicircular edge (30.*), but gradually narrowing and terminating in a little projecting internal tubercle (30.†), between which and the upper edge of the outer semicircular margin, on the top of the bone, is a broad hollow in which the spoke-bone rests and moves.

The Spoke-bone (Q. R. vii.) is more cylindrical and much more slender; when at rest, it stretches beyond

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the base of the cubit, and seems to be longest, but this arises from its hinder extremity or head being in front of the articular cavity of that bone. The head (33.) is round and cup-shaped, for the upper pulley of the upper arm-bone, and its under half smooth to rest in the lesser sigmoid cavity of the cubit, in which it moves backwards and forwards in expanding or closing the wing. The anterior extremity or base (34.) of the bone expanded laterally, and, curving down upon the base of the cubit, has a broad convex articular surface (34.) at its end for the upper wrist-bone; and on its upper surface a wide groove (34.*) for the passage of the tendons of the extending muscles of the hand. The Spoke-bone has no rotatory motion upon the cubit, but simply slips backwards and forwards upon it; supination and pronation of the Fore-Arm are however to a certain extent effected by the obliquity of the radio-humeral articulation at the elbow-joint.

With few exceptions there is little variety in the Fore-Arm. In the *Emeu* the Fore and upper arm are of nearly equal length; but the two bones of the latter are cylindrical, of nearly equal size, but expanded at their extremities. In the whole Family of *Diving* Birds the Fore-Arm is short and flattened, especially in the *Puffins* and *Auks* (fig. 23. VI. and VII.), but in the *Penguins* (fig. 8. VI. and VII.) the bones are very flat and wide from before backwards; they are also permanently prone, and the front edge of the spoke-bone is very sharp, as also is the back of the cubit, which below forms a sharp angular process, whilst at the upper part it is much less wide, and seems to have no olechranon, which, however, really exists as a separate bone (*), irregularly triangular on the outside, and having from the lower part of its inside a little projecting process with a sharp narrow ridge to lodge in the small pulley of the upper arm, whilst its more elevated part rests against its outer surface. The difference of length has been sufficiently noticed in observing on that of the upper-arm.

The *Wrist* of Birds consists of but two bones, the form of which and their use are peculiar to the Class.

The Radio-carpal bone (Q. R. VIII.) attached to the base of the spoke-bone, forms as it were a cap to the froot of the Wrist-joint. More or less transversely oblong in front (37.), but deepest on the inner edge, it has, above, a wide articular surface (38.), concave from before, backwards and slightly concave from side to side, for the spoke-bone; below, it has another, but much larger, concave surface (39.), facing outwards and downwards, which forms part of the socket for the upper end of the great palm-bone; and behind it has a third concave surface (40.) for the articular base of the cubit.

The Ulno-carpal bone (Q. R. IX.), placed beneath the anterior articular surface of the cubit, has a very peculiar form; its upper surface (41.) is concave from before backwards to correspond with the articular surface of the cubit; below, it bifurcates into two processes separated by a deep notch, an external short one (42.), received into a hollow at the upper and back part of the palm-bone, and an internal longer one (43.), which passes on the inside of the same bone.

In the *Nandu* the Radio-carpal bone has the usual form, but the Ulno-carpal is merely a little conical bone, the base attached to the cubit, and the apex running on the inside of the palm-bone; it has a very small projection on the outer side, so that the groove for that bone scarcely exists. In the *Ostrich* (fig. 7. VIII.) the Radio-carpal bone is like a split pea, hollowed where it rests against the spoke-bone, but rounded behind where it articulates with the upper palm-bone; the Ulno-carpal bone (IX.) is bean-shaped, but one of its long surfaces joins the cubit before, and by the other the two lower palmar bones behind; its upper end is in contact with the radio-carpal bone. In the *Penguins*, the Ulno-carpal bone (fig. 8. IX.) is largely developed, flat, and hatchet-shaped, with its edge turned backwards; its triangular-shaped head has one articular surface behind for the cubit, and another before for the palm-bone. The Radio-carpal (VIII.), thin and flat, is, as usual, between the spoke-bone and palm-bone.



The remaining bones form or correspond to the *Hand* and *Fingers*.

The Palm or Metacarpal bone (Q. R. X.) single, although its original composition of three is distinctly perceptible, when folded on the fore-arm hangs downwards, backwards, and outwards. It has two long shafts connected together above and below, but widely separate in the middle, and of these the anterior (44.) is considerably largest, and has the third piece (46.), which is very short, and sometimes a mere stud, completely consolidated with its fore and upper part. On the upper end of the bone is a large articular surface (47.) for the cubit and radio-carpal bone, convex from before backwards, and concave from side to side, with its plane facing obliquely outwards; the inner edge (48.) is sharp, and descends far back, forming a keel, which is received within the cleft separating the two processes of the ulno-carpal bone; close to its termination behind is a pit in which rests the short outer process of that bone, and upon the inside of the head a little tubercle (49.) for the attachment of its inner long process. Before and below the upper articular surface is a compressed, more or less projecting process (50.), to which the tendons of the radial extensor muscles are fixed; and continued more or less downwards is a ridge (46.), the analogue of the palm-bone of the thumb, having a triangular articular surface at its tip, upon which is fixed the thumb (51.), a single, long, three-sided pyramidal bone, with, in some instances, a very slender, short, second piece forming its tip. The anterior and principal shaft (44.) flattened and cylindrical, marked with ridges and grooves, has at its lower end a large, irregularly flattened articular surface (52.) for the first piece of the finger. The posterior shaft (45.) very slender, commences at the termination of the inner edge of the carpal pulley, has sharp edges and grooves along its middle, joins the back of the front shaft below, and also spreads to form an articular surface (53.) for the second finger. In the *Nandu*, the Palm-bone has the general form, but is very short; the stud for its thumb, however, is lengthy, as is also the single joint of the thumb itself. The same characters belong to the *Ostrich*, but the palm is shorter. In the *Emeu*, the Palm-bone (fig. 18. A. x.) is little developed, irregularly cylindrical, and thicker above than below; a very slight rudiment of the second shaft (45.) exists, in a little thin bone, about the size of a large common pin, which is anchylosed, except at its tip, from the upper and to the middle of the great shaft.

The motions of the bones at the Wrist-joint upon each other it is very difficult by words to explain. When at rest, the carpal end of the palm-bone is applied by both



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its edges and concavity to the radio-carpal bone, and the hind part of its inner edge received into the fork of the ulno-carpal bone, but scarcely, if at all, touches the carpal end of the cubit. Upon extension of the hand, however, the ulno-carpal bone moves forward upon the cubit, the upper part of the inner edge of the palm-bone descends into the fork of the ulno-carpal, and the outer half of its articular surface is brought into contact with the corresponding part of the cubit, the radio-carpal and spoke-bone being simultaneously retracted on the cubit so as to give room for this apposition.

The analogues of two Fingers (Q. R. xi.) exist besides the rudimental thumb already mentioned. The principal finger in front consists of two pieces or joints; the upper (54) has a large irregular flat head for its junction with the palm-bone; is thick and flat on its front edge, and a little below the joint sends out a deep thin blade (55.) behind; its lower end has a triangular articular surface (56.) for its junction with the lower piece (57.), which is of a trigonal form gradually tapering towards its tip, and in *Web-footed* Birds has commonly attached a very minute third joint. The small finger (58.) is a short single bone joined to the lower end of the hinder shaft of the palm-bone, and attached behind the principal finger upon the space above the blade of the latter bone. In the *Nandu* the joints of the finger are extremely short, but very deep. In the *Ostrich*, the small finger (fig. 7. 58.) has a pointed second joint covered with a claw; the principal finger consists of three joints, and the extreme one is clawed; the thumb has also a second clawed joint. In the *Emeu*, there is but a single bone (fig. 5. 54.) to the finger, and this is clawed.

An interesting analogy between the Wings of Birds and the Fore Limbs of Reptiles, and also of Beasts, has been pointed out by Nitzsch,* but is unnoticed by any other zoologist, although it must have been observed frequently by such as have been accustomed to prepare skeletons for their own use. It consists in some of the Finger-pieces being armed with claws, and of these the thumbs are most commonly so provided. It occurs generally, though not always, in the *Diurnal Rapacious* Birds, thus in the *Kestril*, but not in the *Buzzards;* nor is it found in the *Owls*. Among the *Passerine* Birds it is only seen in the *Swifts*, in which it is very large. Many of the *Waders* have it, and in some, as the *Crane*, it is nearly half an inch long. In the *Gallinaceous* Order, as the *Common Fowl* (fig. 6. Q. R. x. 51.), and among the *Web-footed* Birds, as the *Common Goose*, *Duck*, and *Gannet*, it is long; but in the *Gulls*, *Larus*, and *Sterns*, *Sterna*, it is generally short. The principal finger is far less frequently armed with a claw, but it is found in the *Ostrich* and *Emeu* as above mentioned. Upon the little finger no claw is found, except in the *Ostrich*.

In many Birds the capsules of some of the Wing joints are furnished with little accessory bones, of which the use is to render the play of the tendons more free, and to lengthen the levers of the bones to which they properly belong. They are found at the shoulder in the *Hawks*, *Owls*, and most *Passerine* Birds, but not in the *Wading* or *Gallinaceous* Orders. Also at the elbow and wrist of the *Swift* and others.

*General Structure of the Wings.*—Having thus described the bony framework of the Wings, it will be now convenient to notice their general formation. When denuded of feathers and expanded, the bony parts are obscurely seen through the skin, within which they are contained. They do not, however, as might at first be supposed, stretch out in a straight line from the shoulder, but produce three angles, the inner one looking backwards, formed by the upper arm stretching backwards and outwards from the side of the trunk; the middle one opening forwards, formed by the upper and fore-arm, and the outer one looking backwards, and formed by the fore-arm and hand. The object of this angular arrangement is to produce a broad surface for the wing, which is effected first by the doubling of skin, which forms the posterior or upper margin of the arm-pit passing broadly from the trunk to the back of the upper arm; and, secondly, by the extension of an elastic ligamentous rope between the front of the shoulder and the base of the spoke-bone, over which the skin is folded, and passes backwards to be attached along the whole length of the upper and fore-arm, thus forming a triangular sail with its base in front. A second similar rope and doubling of skin stretches from the back of the middle of the fore-arm to that of the hand, but the triangular sail here formed is less wide from before backwards than the front one. The expansion of these membranes, which, in flight, require to be kept tense, is effected simply, but beautifully, by the mere extension of the bones; the muscles drawing the upper arm forwards, stretch the inner or thoracic humeral sail, those which extend the fore upon the upper arm, by drawing it back, tighten the middle sail, and those which bring forward the hand upon the fore-arm outstretch the outer sail.

The extent of the Wing's surface is further increased by the attachment of large feathers, which, from having their barrels or quills lengthy, are called *quill feathers*, of which there are three sets, classed according to their attachment on the hand, fore-arm and upper-arm, and the different length of the members, principally of those belonging to the hand, form oftentimes a generic character. All the quill feathers attached to the hand are, from their position on this, by ornithologists, called the first bone of the Wing, named *Primaries* or *Primary Quills*, or, from their larger size and action, *Greater Remiges*, the first or outermost lies in the same plane with the front of the hand, but the others spread gradually backwards like the open sticks of a fan. The *Secondaries*, *Secondary Quills*, or *Lesser Remiges*, are fixed upon the upper surface of the fore-arm. The *Tertials* are attached along the whole length of the upper arm; and upon the shoulder-joint and edge of the blade-bone are the *Scapulars*. To the thumb are also attached some small quills, which are called *Bastard Quills*, or the whole together, the *Bastard Wing*. The roots of the quill feathers are concealed by successive layers of feathers, of which the size gradually diminishes to the front edge of the Wing, where they interweave into a sort of selvage with the short feathers which overspread the under or inner surface of the Wing; all these feathers are called *Coverts;* those overlapping the primaries and secondaries are the *Greater;* those upon the tertials, the *Lesser;* and those on the under surface of the Wing, the *Under Coverts*.

B. *Of the Legs.*

The *Hip-Girdle* of Birds is characterized by the union of its lateral portions with the vertebers of the loins and rump, except in the *Penguins*, in which they

* See his *Osteografische Beiträge zur Naturgeschichte der Vögel*, p. 89.

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Zoology. remain distinct, by its share-bones being unconnected with each other, so that the fore and under part is deficient in the whole Class, excepting in the *Ostrich* alone, which has the pelvic ring perfect, and by the Hip-sockets being simple round holes, their bottom filled with ligament instead of being perfect bony cups. The back and upper part of the Hip-girdle is formed of the loin and rump vertebers already described, upon the breadth of which largely depends that of the Girdle; its sides by the pair of Unnamed, or, as Meckel calls them, Lateral bones, each consisting, as in Reptiles, of three pieces whilst the bird is young, but becoming consolidated very early.

Of the Unnamed bone (fig. 6. G. H.), all that portion which is before, above, and behind the Hip-socket, and in contact with the vertebers interposed between itself and its fellow, is the so-called Hip-bone (I.), forming more than the upper half of the socket (ω.), in front of which it expands into a more or less spacious surface or belly (I.), concave laterally above for the lodgment of the gluteal muscles, convex beneath (I.), resting upon and generally anchylosed with the transverse processes of the two or three last back, and all the loin vertebers, its free anterior part (I.*) overlapping some of the hinder ribs, and its inner hinder edge (I.†) generally uniting with the ridge of the neighbouring vertebral spines, so that it forms a perfect canal (2.) for the lodgment of muscles, sometimes open behind, as in the *Common Fowl*, or closed as in the *Hawks*, *Ducks*, &c.; in the *Guillemots* and *Divers* (fig. 12. B. I. 1.), this part is very narrow, and, in the latter especially, scarce rises above the vertebral transverse processes. The ring of the Hip-socket (ω.) is the thickest and strongest part of the bone, and is deepest and spread most outwards at the back part (ω.*), for the neck of the thigh-bone to rest against, not to support. Behind and above it the Hip-bone stretches to a greater or less extent backwards (3.), farthest in the *Water*, and especially in *Diving* Birds, and least in the *Rapacious* and *Wading* Orders; and it spreads either horizontally as in *Land* (fig. 6. I. 3.), or more or less obliquely downwards as in *Water* (fig. 9. I. 3.), and specially in *Diving* Birds, of which the *Divers* (fig. 12. I. 3.) are a good example: its inner edge (3.†) joins the tips of the transverse processes of the rump vertebers, and its outer (3.*), in most instances, is consolidated with the haunch-bone, without any definite boundary between the two, an oval aperture, the ilio-ischial hole (χ.) only, immediately behind the Hip-joint, separating them to a greater or less extent. In the *Rapacious* and *Wading* Orders this part of the bone has a flat upper surface, and at the outer part bends suddenly down at an angle to join the haunch-bone, the angle not unfrequently projecting to form a distinct and under cut lip, as in the *Rapacious* Birds (fig. 1. 3.*). The same disposition occurs, but less distinctly, in the *Gallinaceous* Order, in which the breadth of the flat surface (3.† 3.*) is greatest, especially in the *Bustards*, which have the widest Hip-girdle: in the greater number of *Passerine* Birds, also, this part of the bone is wide. In the *Ostrich* Family the hinder part of the Hip-bone exhibits some peculiarities; in the *Nandu* (fig. 16. C. 3. 3.*) it is but little more than half the length of the haunch-bone, with which however it has an osseous union: in the *Cassowary* their length is equal, and they are similarly united; the margins of the ilio-ischial hole are therefore in both entirely bony; in the *Emeu*, they are not united; in the *Apteryx* (fig. 17. C. I. 3.) they are widely distant throughout their whole length, and still more so in the *Ostrich* (fig. 7. 3.); no aperture, therefore, but only a deep cleft, exists in the latter two Birds. The under and back part (4.) of the Hip-socket (ω.) stretches back, as the Haunch-bone (II.), which is immediately more or less contracted (5.) to form above the lower edge of the ilio-ischial (χ.), and below the upper edge of the ischio-pubic or oval hole (ψ.); continued farther back, it perfects the former hole, and unites with the hip-bone throughout the rest of its extent (6.), and in the same plane with it, in the greater number of Birds. In the *Ostrich* Family, however, as already mentioned, the boundaries of the two bones are very definite, even in the *Cassowary* and *Nandu*, in which they unite; but in the latter, the Haunch-bones (fig. 16. II.) are very remarkable, on account of their inclining inwards towards each other, and uniting (††) a short distance behind the Hip-sockets, and thence continuing backwards, united throughout their whole length, and forming a second roof above the pelvic cavity. In the *Apteryx* (fig. 17. C. II.) these bones are very deep, and completely distinct below from the share-bones; in the *Emeu* they are widely separate, but their tip is expanded, as also they are separate, though less widely, in the *Cassowary*; but in the *Nandu*, the extremities of both Haunch and Share-bones are closely approximated and connected by ligament; and in the *Ostrich* (fig. 7. II.), by bone, the hind end of the Haunch expanding and descending to join the Share-bone. From the fore under and outer part of the Hip-socket projects a little stumpy process (7.), which is the spine of the Share-bone (III.), itself forming the margin of the ring between the Hip and Haunch-bones; thence it continues backwards as a slender style (8.), perfecting the oval or ischio-pubic hole by joining the haunch-bone a little behind the Hip-joint, and afterwards running along the lower margin of that bone, more or less close, till it reaches its hind extremity, beyond which it is continued, and curves more or less inwards, widening slightly at its tip (9.); in the *Divers* (fig. 12. A. III.) the tip is much expanded, and approaches very near its fellow; in the *Hawks* (fig. 1. III.) it is a very slender and simply curving bone, and not unfrequently, just behind the oval hole, is deficient, thus forming two distinct pieces (8.), which are connected by ligament. Sometimes the Haunch and Share-bones are not connected behind the Hip-socket, and the oval hole is then confounded with the space between the hinder edges of the two bones, as in the *Parrots* (fig. 4. 5. ψ.), &c. The Share-bones in the *Ostrich* Family, excepting in the *Ostrich*, are scarcely so long as the Haunch-bones, and do not belly much outwards, the lateral extent of the Hip-girdle is therefore not great; their form is somewhat trigonal, and they thicken, especially in the *Cassowary*, towards the extremity, excepting the *Apteryx* (fig. 17. III.), in which they taper almost to points. In the *Ostrich* (fig. 7. III.), however, the Share-bones spread much outwards, and render the fore part of the Girdle very wide, incline inwards behind, and having joined with the Haunch-bones, each sends downwards, inwards, and forwards, a curving process (9.*), which meets its fellow in the mesial line, and thus renders the Hip-girdle a perfect though irregular ring, the only known instance of the kind in Birds.

The *Leg* consists of the thigh, leg proper, shank, and foot, which do not form a vertical support to the Bird, for were it so, as the hip-joint or centre of support

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is so far behind the centre of gravity, the muscles required to retain the trunk in its natural position would need to be of most enormous size. The support of the body is, however, effected by a very simple but beautiful disposition of the leg-bones, which at the same time provides a set of powerful springs, so that not only is the weight of the body transmitted to the ground without jarring in its ordinary motions, but even when, as it often happens, the bird drops suddenly from a great height on its feet, it receives no injury. Strange as it may at first seem, the hip-joints are not, but the knee-joints are, the actual supporting points of the trunk, from which also the motions of the leg are performed, and these are brought to, or near to, the centre of gravity of the body, a little in front of the hind margin of the breast-bone, by the oblique direction forwards of the thigh-bones, so that the insides of the knees rest against the sides of the chest. From the knee-joint the leg stretches obliquely backwards and downwards to such extent that the ankle, or, as it is in Birds commonly called, the knee-joint is nearly in the same vertical plane with the hip. From the ankle, the instep-bone, or, commonly so called, leg stretches obliquely forwards and downwards, and its junction with the roots of the toes is in the same vertical plane with the knee-joint. Thus are there in front two open angles, the upper between the spine and thigh, the lower between the leg and instep-bone, and two open angles behind, the upper between the thigh and leg, the lower between the instep-bone and ground; by diminishing these, the foot is raised from the ground, and the limb being thus swung forward from the knee, the angles are opened, and the foot brought again to the ground, an alternate repetition of which motions by each limb produces progression. The angles are sustained by the beautiful contrivance of the more powerful muscles not being attached to the immediately adjacent bones, but passing from above one joint over a second, on which they usually become tendinous, to be inserted in the bone below, so that if the latter be firmly sustained in its position, the more the bone whence the muscles arise is loaded the more perfectly is the angle and its springiness preserved. Thus the great muscles which support the hip-girdle on the thigh pass from the hip-bone in front of the hip-joint and thigh over the knee to be attached to the leg-bone, and those which support the thigh upon the leg pass from the thigh-bone over the back of the knee-joint and leg, and over the back of the ankle-joint, to be affixed to the instep-bone.

The Thigh-bone (fig. 6. R. 1.), although the most bulky, is generally the shortest of the three portions of the leg; but it has nearly the same general form in all. Its shaft or middle (12.) is tolerably cylindrical, sometimes flattened a little on the outside, as in the *Ducks*, or compressed laterally as in the *Mergansers*, and in the *Divers* (fig. 12. 1. 8.*) still more, so that on its hinder surface a distinct sharp edge or rough line is produced: it is also slightly arched forwards; but in the *Divers* very considerably. At both extremities the bone spreads laterally, and is flattened from before backwards. On the inside of the upper end is attached, at a right angle with the shaft, the nearly hemispherical head (10.), which is received into the hip-socket, distinguished principally by its smoothness, but not supported on any special neck or lengthened process: from its upper surface an articular surface (10.*) stretches outwards of correspondent extent to the length of the lateral extension of the hinder upper edge of the hip-socket, and the outer side of the bone generally rises a little above it as a rudimental greater trochanteric process (11.), which is very distinct in the *Gallinaceous* (fig. 6. R. 1.) and *Wading* Birds; and in such as have the Thigh-bone filled with air, an aperture (11.*) exists on its fore part for the entrance of the membranous air-tube. The lower end of the bone is of considerable size, and furnished with a pair of rounded articular surfaces or pulleys (13. 13.*) widely separated by a broad deep groove, in which the little knee-cap and large extensor tendons of the leg play; and the groove is continued far up in front by the extension of a ridge above each pulley upwards on the shaft: both pulleys are wider behind than in front; the inner pulley (13.) is the shortest but widest, and rests on the shin-bone alone; the outer (13.*) is the longest but narrowest, and its inner edge considerably lengthened, drops between the shin-bone and the inside of the splint-bone, the top of the latter being received in a deep chase (†.) to its outer side.

The *Leg* consists of three bones, the shin-bone and knee-cap, and the splint-bone; the latter of these serves to widen the articular surface at the knee-joint for the thigh-bone, and also, by its ligamentous connection with the shin-bone, produces a spring which diminishes the shock produced by putting the foot to the ground.

The Shin-bone (fig. 6. R. 11.) is invariably the longest portion of the lower extremity, its shaft (16.) cylindrical, and slightly flattened from before to behind. The upper end (14. 14.* 14.†) of the bone is very much expanded, and is of an irregularly square form; it is divided by a more or less distinct middle elevation (14.) received in the pit, at the bottom of the thigh-bone into two articular surfaces, of which the inner one (14.*) is largest, concave from before to behind, and from side to side, for the corresponding pulley on the thigh; the outer one for the outer pulley (14.†) is convex, and the articular surface descends most deeply on the outside. These articular surfaces occupy scarcely more than the hinder half of this end of the bone, of which the rest is formed by the widely expanded base (15.*) of the large tubercle (15.), which generally curves upwards in shape of a wide lip, and prevents the dislocation of the thigh-pulleys forwards, when the knee is much bent, although in the common flexion of the limb they rest against the back of the lip. In the *Mergansers* the lip rises in front of the knee-joint as a little pyramidal process; but in the *Divers* (fig. 12. 11. 15.) it is of enormous length and strength, being as long or longer than the thigh-bone; it rises above the knee-joint like the handle of an oar; and is a most important adaptation of the limb for diving; it has at the back of its root a concave articular surface for the inner thigh-pulley, against which the movements of the knee-joint are performed. The lip is extended outwards (15.†), and prevents the head of the splint-bone being thrust forwards. The tubercle itself projects in front as a sharp thin compressed process (15.), and is lost upon the shaft. A little below the head on the outer side a sharp ridge is formed for the connection of the splint-bone; the lower end (17.) of the Shin-bone expands laterally, and forms behind a single pulley surface (17.), convex from above downwards, and concave laterally for the passage of tendons; and in front it has a pair of articular convex surfaces (17.* 17.*), widely separated by a deep depression, above which in front, but still

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between the articular surfaces, there is in the *Stork* a very remarkable deep cup (fig. 24. A. 17. ††). for a purpose to be presently mentioned. From the upper part of each articular surface a more or less sharp ridge ascends on the front of the shaft, leaving a deep and wide groove between them, in which the tendons of muscles lie confined by a strong ligamentous band; but besides this, in almost all Birds except the *Parrots*, a bony band (18.) passes deeply and obliquely upwards, from above the outer articular surface to the inner ridge, forming a distinct bony canal for the long common extensor muscle of the toes.

The Knee-cap (fig. 6. III.) is really only a movable part of the tubercle of the shin-bone, on the top of which it is generally attached; it is mostly of but small size, wide transversely, with a pair of articular surfaces for the thigh-pulleys at the back; but in the *Web-footed* Order, in which the knee is constantly much bent, it is larger and squarish, so that the thigh-bone rests against it, as in them the base of the tubercle of the shin-bone is low: in some instances it is extremely small and roundish, but is increased in size by being enveloped in a mass of fibro-cartilage. In the *Divers* (fig. 12. C. III.) it is a long thin pyramidal bone, which rests on the side of the elevated base of the shin tubercle.

The Splint-bone (fig. 6. IV.), situated on the outside of the shin-bone, is above, wide from before to behind, and much compressed from side to side; upon its top is a large convex articular surface (20.), received into the chase of the outer condyle; below, the shaft (21.) in general tapers gradually to a thin point (22.), which rests on the side of the shin-bone. Its length varies considerably; sometimes is only half, sometimes not so much, sometimes more than that of the shin-bone; it is shortest in the *Parrots* and *Ducks*, and generally longest in the *Rapacious* Birds; but in the *Cormorant* and *Penguin* it descends nearly to the bottom of the shin-bone.

The Shank-bone (fig. 6. V.), or leg, as it is commonly called, is one of the most remarkable characteristics of Birds, including in itself alone the several bones (except one) which are found in the instep and sole of Reptiles; and, except in the *Parrots* and *Penguins*, is the second longest member of the lower limb. Its shaft (28.) is squarish, with its sides rounded, its front deeply grooved, laterally almost from end to end, and its back also, though but slightly except in those Birds which grasp very powerfully, as the *Rapacious* and *Climbing* Orders, in which the front is rounded, and the back deeply and widely grooved. The upper end expands from side to side, and has a pair of concave articular surfaces (26. 26.), separated by a middle ridge (26.*), for the correspondent surfaces, and depression on the lower end of the shin-bone. The ridge in the *Stork* (fig. 24. B. 26.*) rises up in front into a remarkable rounded process, received when the ankle-joint is half bent into the cup of the shin-bone already mentioned. Its use in the skeleton cannot be comprehended, but whilst the bones remain connected by their ligaments, it exhibits a most beautiful contrivance, by which the vertical position of the leg and instep-bone is preserved without the least muscular exertion, the side ligaments of the joint passing so obliquely backwards from the shin to the shank, and being only sufficiently long as to remain unstretched when the shank is bent forward, that when the latter is straightened upon the former they are stretched, and in endeavouring to relieve themselves, jerk this little process forward, and render it an obstacle to flexion, until overcome by the special action of the flexing muscles. Below and behind the joint are more or less projecting ridges (27.), generally forming deep grooves for the lodgment of tendons, and not unfrequently two or more coalesce and form distinct canals. The lower end of the bone expands laterally in an arched form, grooved longitudinally in front, and forming a wide channel behind (30.), for the extensor and flexor tendons of the toes, and is finally divided into three knuckle-like pulleys (29. 29. 29.), distinctly separated by deep clefts; of these pulleys, the outer two are convex from before backwards, and concave from side to side; the inner is simply convex, and has a little stud at its inner hinder edge; the middle pulley is longest, and faces directly forwards; the toe attached to it is therefore straight in front; the others decline from it, and thus the inner and outer toes spread in contrary directions. Above and between the outer two pulleys the bone is perforated from before backwards by a small hole (31.), for the passage of a tendon; and above the inner pulley a little rough surface (32.) gives attachment to the small Instep-bone (33.) which supports the thumb. This, which is the only distinct representative of a sole or metatarsal bone, is flattened laterally, and stretches obliquely backwards and downwards; its upper rough end joins by fibro-cartilage to the Shank-bone, and the lower, expanded outwards, forms a single convex pulley for the thumb, and widens the broad hollow for the flexor tendons of the toes. The Shank-bone in the *Parrots* (fig. 5. 4. V.) and *Maccaws* is remarkably short but very wide, especially at bottom, and the outer pulley (28.*), instead of facing forwards and outwards, is twisted almost directly backwards, consequently two toes only are in front, and the other two behind; hence to all the *Climbing* Birds thus constructed Temminck has applied the term *Zygodactylous*, or yoke-toed; sometimes this pulley is so formed that the outer toe can be turned forwards or backwards, as in the *Cuckoo*, *Cuculous canorus*; the *Owls* also have the same power of turning this toe round; but in the *Woodpeckers* (fig. 3. E.), and *Wrynecks*, *Yunx*, it is always backwards. In opposition to this arrangement, the Instep-bone is sometimes directed outwards instead of backwards, and included in the web of the foot, which then is quadrant-shaped, with its arc inclined inwards and forwards, as in the *Cormorant* and *Gannet*, but in the *Swift* (fig. 10. G.), it is inclined still more forwards, so that the thumb has a corresponding direction inwards to that of the outer toe outwards. The most remarkable form, however, of the Shank-bone is that of the *Penguins*, (fig. 8. E.), in which it is short, extremely wide, and the pulleys separated by deep clefts which reach nearly to the ankle-joint, so that the bone appears as if consisting of three distinct pieces or sole-bones, consolidated only at their hinder ends, and this resemblance is increased by the whole length of the bone being on the same horizontal plane as the toes, consequently resting on the ground as in most Toed Reptiles. Sometimes the Instep-bone is unconnected with the Shank-bone, and suspended only in the skin as in the *Petrels*; sometimes it is entirely deficient, and but three toes exist, as in the *Plovers*; and in the *Ostrich* there are but two pulleys, the inner toe being deficient.

The Toes (fig. 6. R. VI. VI.*), of which there are generally three in front (34. 34. 34.) and one behind (34.*), often called the foot-thumb, consist of several

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Zoology. joints, of which the usual number is two to the thumb, three to the inner, four to the middle, and five to the outer toe; but many variations occur in these relative numbers. The pieces generally of the inner and middle toes are the longest, and of the outer the shortest; but though ordinarily the middle toe is longest, yet in the *Diving* Birds it is not longer than the outer toe; the hinder ends or bases of all the joints are usually concave vertically and laterally, and divided into two articular surfaces by a vertical ridge, to correspond with the head of the joint behind, which is convex vertically and laterally, but divided by a deep vertical groove; the bases of the first joint of the thumb and inner toe, are, however, simply concave, to answer to the corresponding articular surface on the shank and instep-bones. The last joint of each toe is enveloped in a horny claw, whence it is called the claw-joint; and in accordance with the size and curve of this joint is a little eminence on the under surface of the bone near its base, which prevents the sharp points of the claws being blunted by constant friction against the ground. The bulk, length, and strength of the toes varies considerably, and form a good indication of the habits of the bird, thus in the *Diurnal Rapacious* Birds (fig. 1. vi.), they are large and powerful, especially the thumb and inner toe, and the claw-joints large and strongly curved; in the *Moorhen, Coot* (fig. 25), and the like, very long and slender, and straight, and the claw-joints also straight: in the *Gallinaceous* Birds (fig. 6.), which seek their food by scratching the earth, the toes are short and stout, and the claw-joints but little curved: among the *Web-footed* Birds the toes are generally slender, and of varying length and curve of their claw-joints, but in the *Divers* (fig. 12.), they are long, slender, and straight.

### Of the Skeleton of Beasts.

The walls of the bones in this Class are generally thick and strong, in proportion to the size of the animal; and their interior cellular structure containing fat, but never receiving air, as in some of the Birds. Although considerable modification of the Skeleton exists in different Beasts, more especially in reference to the form and arrangement of the motive organs for effecting the several functions of swimming, flying, running, jumping, and holding, yet all are formed on one great type, presenting well-defined characters.

The principal peculiarities in the Skeleton of Beasts are the following:—the connection of the bodies of the vertebral pieces to each other by correspondently shaped fibro-ligamentous masses, tough and unyielding at their circumference, but gradually softening and becoming almost pultaceous in the centre, and strongly recalling the ligamentous collars and fluid axes of the spine in Fishes: the first and second neck vertebers are the only exception to this kind of union, their connection being true joints, with cartilaginous surfaces and synovial capsules: the provision of the first verteber with a pair of sockets for the reception of a pair of skull-condyles, very slightly indicated in Fishes, whilst in Birds and Reptiles, a single condyle and socket unite the skull and spine; the larger size of the skull in proportion to that of the face certainly in comparison with that of Fishes and Reptiles, but not throughout the whole Class, as compared with Birds; and the small number of skull-bones by the actual consolidation of several, in the other Classes distinct, pieces into one, as, for instance, of the occipital pieces of Fishes and Reptiles; of the pterygoid and sphenoid bones of Reptiles and Birds, of the squamous, mastoid, tympanal, and petrous bones of Reptiles, and of the temporal and tympanal bones of Birds; the immovable connection of the face-bones, excepting the lower jaw, with the skull, and the pair of pieces of which that jaw alone consists;—all the front ribs connected with a long narrow breast-bone of more or less pieces, all the free or floating ribs behind, and none in front, as in Birds and Reptiles;—the loins consisting of several movable pieces, not as in Birds anchylosed to the hip-bones, and only in a few instances, the transverse processes of the last piece articulating with them;—but very few rump vertebers connected with the hip-bones, and all those of the tail, except in a few species, perfectly independent of the hip-girdle;—the shoulder-girdle never consisting of more than two pairs of bones, one pair connecting the other with the breast-bone, sometimes however no direct connection of these pairs with themselves or with the breast-bone, and at other times, one pair actually deficient, the blade-bones which always exist of larger size than in either of the other Classes;—the wrist-bones more numerous than in Birds or Reptiles, and the fingers generally, though not always, more than in Birds;—the ring of the hip-girdle perfect, with but very few exceptions;—the hip-cup perfect, and entirely bony, for the reception of the head of the thigh-bone, which alone articulates with it, and the latter connected to its shaft by a more or less long neck, so that the trochanteric process is quite independent of the hip-joint—the splint-bone never entering into the composition of the knee-joint, and sometimes, as in Birds, not reaching the ankle-joint; the instep-bones always distinct, and more numerous than in Reptiles; and the toes, with their sole-bones, generally five, but sometimes four, three, two, or even one.

### 1. Of the Spine.

The Spine of Beasts is, with few exceptions, like that of Reptiles, in a horizontal posture, but differs in many Families in the front of the neck being elevated above the trunk, occasionally, indeed in the long-necked Beasts, as the *Horse, Camel*, and others, to a considerable height, in which case it affects the reversed Italic *f* shape of the neck of Birds, without, however, being generally capable of diminishing its length by increasing the curves. The Spine is more importantly distinguished from that of Birds and Reptiles, by the union of its columnar pieces being effected, not as in them by true joints, *i. e.* by the ends of the corresponding bones being covered with cartilage and enclosed in a synovial capsule, but by concentric circles of ligamentous substance, thick and close at the margins of the bones, which gradually becomes of more loose texture, by the lengthening of the connecting tissue towards the centre of this (as it is called) intervertebral substance, so that the central part seems almost pultaceous; being enclosed however by the external, close, circular fibres, it is perfectly confined, and serves as an incompressible centre, upon which the restricted motions of the vertebral bodies are performed, precisely in the same manner as the vertebral bodies of Fishes move upon the fluid contained within their connecting ligamentous rings. The bodies, however, of the first and second neck vertebers must be excepted, their junction being a perfect joint. The connection of the articular processes throughout the whole Spine is like those of Birds and Reptiles, by true joints. The Spine of Beasts presents the same general division into neck, back, loins, rump, and tail, as in Birds and

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Reptiles, but is distinguished from the former in the non-consolidation of the back vertebres* into a mass, and in the absence of bony union of the consolidated rump vertebres with the other bones of the hip-girdle; and from the latter by the bony connexion of the rump vertebres together.

The *Neck*.†—The general, indeed almost universal number of vertebral pieces in this region (A.) of the Spine is seven. This number is only exceeded by one in the *Black-collared Sloth*, *Brodypus torquatus*, which has eight, and by two in the *Aï*, *Brad. tridactylus* (Skel. Pl. IV., fig. 5. A. A.*), which has nine; unless, as regards the latter animal, Bell's opinion be assented to, that the loose processes first noticed by him as attached to the transverse processes of the eighth and ninth vertebres, are rudimental ribs corresponding to the front ribs of Birds, which are unconnected with the breastbone; under this view, the usual number of Neck vertebres would not be exceeded, the lower two being included among those of the back. It is most probable, however, that these so-called ribs are really only jointed transverse processes (g.), such as exist in the *Crocodiles*, and of which indeed the pivot vertebre of the *Ornithorhynque* (fig. 13. a.) is an example among Beasts. Instances of a smaller number than seven vertebres are very few, and observed only in the Spouting Family of Cetaceans; generally, five separate ones are distinguishable besides the first two, which are consolidated as in the *Porpesse* and *Whale* Tribes; but in the *Bottle-nosed Dolphin*, *Delphinus tursio*, only four distinct vertebres behind the consolidated front two can be enumerated; unless the immediately following one, which supports the first pair of ribs, and is considered by Hunter and Rudolphi common to the Neck and back, be held, as by Meckel, for the last Neck vertebre. Among the Grazing Cetaceans, although Meckel doubts Home's statement, the *Dugong*, *Halicore dugong*, (fig. 1. A.), at least the young specimen in the Museum of the Royal College of Surgeons, London, has certainly seven distinctly separate Neck vertebres. But in the *Manatee*, *Manatus Americanus*, in the same collection, only six of these vertebres exist, as observed also by Meckel in three specimens in the Museum at Munich, and which had also been previously noticed by Cuvier, Steller, and Daubenton. From this prevalent restriction of the Neck vertebres to seven, it is evident that the length of this region in different Beasts must depend on that of the vertebral bodies themselves; thus, in the Spouting Cetacean Family, of which Meckel computes the Neck at no more than one-fortieth of the animal's total length, the hinder five vertebral bodies are scarcely thicker than stout card-board; whilst, on the contrary, in the *Giraffe*, *Camelopardalis*, in which, measuring from the back of the head to the tuberosity of the haunch-bone, the Neck forms four-ninths; in the *Vicugna*, *Auchenia*, more than two-fifths; and in the *Camel*, *Camelus Bactrianus*, two-fifths of this length, the Neck vertebres, excepting the seventh, are several inches long. And among our own long-necked Beasts, as the *Fallow Deer*, *Cervus dama*, the Neck occupies three-sevenths; and in the *Horse*, *Equus caballus*, one-third of the length already noted, and the vertebral bodies are of correspondent length. Excepting in the Family of Spouters, the bodies of the Neck vertebres are shortest or thinnest in the *Elephants*. The length of the Neck, or rather the conjoined length of the Neck and head, correspond with that of the fore limbs, thus enabling the animal to bring its mouth to the ground in feeding. The exceptions to this rule are the short neck of the *Monkeys*, which carry their food by hand to the mouth; and the *Elephants* provided with a trunk for the same purpose. In the *Seals* and other Amphibious Beasts, also, the Neck is not lengthy, as in the water where they feed the animal is capable of depressing its whole body to the level at which it finds its prey. The width of the Neck is inversely proportioned to its length; thus, it is narrow in the long-necked Beasts, as the *Horse* and *Camel*, and more especially in the *Vicugna* and *Giraffe*; but generally wide in those having short necks, as in the *Elephant*, the *Monkeys*, the *Digitigrade* and *Amphibious Flesh-eaters*, the Insectivorous Family, especially the *Moles*, and most remarkably in the *Armadillos*, *Dasypus*, and in the Spouting Cetacean Family. This depends either on the width of the vertebral bodies, as in the *Elephant*, *Armadillos*, and *Porpesses*, or on the lateral extension of the transverse processes, as in the *Cats*, *Seals*, and *Moles*; in which generally the vertebral arch is also very flat and wide. On the contrary, in the *Horse* and *Camel* the vertebral body is narrow though long; its arch narrow, and either slightly sunken or ridged lengthways in the middle, and the transverse processes not large. When the vertebral bodies are wide, their under surface is either flat, as in the *Cats*, or rounded, as in the *Elephant* or *Camel*; but when narrow and long, the under surface is pinched up into a longitudinal ridge not unfrequently called the anterior spine, as in Ruminant Beasts generally and in the *Horse*. In some instances, indeed, the bodies of these vertebres have well-defined Spines curving backwards, as in the *Ornithorhynque*. The ends of the Neck vertebres in Long-necked Beasts form a sort of ball-and-socket-joint, which is well seen in the *Horse*, the front end of each piece being produced into a semi-oval shaped head facing forwards and downwards, and the hind end cupped and facing backwards and upwards; their obliquity varying in proportion to their more or less horizontal or vertical position in the curve of the Neck. In the *Giraffe* and *Camel-like* Family the cup is shallower, but in the other Ruminant Beasts, and in the True Thick-skinned Family, as *Swine*, &c., it is deeper, and correspondingly is there more or less freedom of motion in the Neck. Some Short-necked Beasts have the ends of their vertebral bodies similarly formed, but the rounded head is much flattened and the cup very shallow, as in the *Dogs*; in others both ends are flat, as in the *Hedgehog*; and in the *Monkeys* and *Lemurs*, although the front end is slightly convex from above downwards, yet on either side it has a slightly elevated lip, so that it seems concave laterally, and the hinder end is correspondently concave and convex, a conformation which, whilst permitting a restricted rotatory motion between adjoining vertebres, strengthens their connexion. In proportion as the Neck curves upwards, the ends of the vertebral bodies are more oblique; and on the contrary, when it is horizontal, these ends face directly backwards and forwards, as in the *Whales* and their like. The front articular processes face more or less obliquely upwards and forwards, projecting slightly before the body of the bone, separated from it by a notch, and from each other

* The last syllable of this word has hitherto been accidentally spelt "ber;" the correct spelling is "bre," thus, "Vertebre."

† In the following description the spine and its vertebres are presumed to be in their naturally more or less horizontal position.



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by a more or less deep notch, as if the vertebral arch were cut away from between them; sometimes their surfaces are on the same plane, and at others inclined towards each other; generally they are flattish, or only slightly concave from side to side, but in the *Vicugna* they are very much hollowed; the hind pair are more distinct than the front, the vertebral arch seeming to be lengthened backwards, their surfaces face downwards, and as to their direction and shape are the reverse of the front ones, with which they correspond, and upon which they move. In all the Spouting Cetaceans, in consequence of the thinness of the vertebral bodies, their arches are completely behind instead of above them, and the articular processes, therefore, not before and behind, but above and below each other. The spinous processes vary in length; in the Long-necked Beasts which have great freedom of motion in the Neck, as the *Giraffe*, *Camels*, *Horse*, &c., the spinous processes, except on the seventh vertebre, in which it is distinct though low, scarcely exist, their only indication being a longitudinal mesial ridge more or less deep upon the vertebral arch. On the contrary, in the Short-necked Beasts, which have either heavy heads or powerful necks, the five lower vertebres are all furnished with spines, which increase in length as they approach the back. These are little developed in the Digitigrade and Plantigrade Families, as in the *Cats* (fig. 9. A.), *Weasels*, *Dogs*, *Bears*, &c., in which the third Neck vertebre is little more than a stud. But in the Hollow-horned Ruminant Beasts, as *Oxen*, *Sheep*, *Goats*, and *Antelopes*, this stud becomes a very decided short spine, which, in the *Equine Antelope*, is of considerable length. The Family of Monkeys have their five lower spines very decided, all vertical, and of equal length (fig. 12. A.), though not very long, except the seventh, which is the tallest. Among them the *Mandril*, *Cynocephalus mormon*, has these spines longest, though slender, and gradually lengthening as they approach the back. The *Chimpanzee*, *Simia troglodytes*, has them of equal length; the third, which projects beyond the tip of the spine of the pivot vertebre, being as long as the seventh, and all pretty stout and with thickened tips, except the third, which is pointed. The *Orang Outang*, *Simia satyrus*, is, however, the most remarkable for the great length of all the spines, which are longer than on any other part of the Spine; the third exceeds that of the pivot by at least half an inch, the fourth longer, and the fifth longest; from which they again shorten towards the back; the front spines are most slender, and they gradually thicken as they approach the back. The *Ornithorynque* is another instance of the great length of the third spine, which equals that of the second; but behind it the other spines shorten and recline till they are succeeded by those of the back. In the Gnawers generally the Neck spines are very low, as they are also in the *Ant-eaters*, in which they have a remarkably compressed triangular form. In the Insect-eaters, as the *Hedgehog*, and more especially the *Mole*, the only indication of spines is a slight mesial elevation at the union of the original two portions of the vertebral arch; and very similar to this appearance is the indication of spines on the Neck vertebres of the *Armadillos* and of the Spouting Cetaceans. The transverse processes are important parts of the vertebres, varying considerably in size and disposition in relation to the strength and kind of motions of the Neck. In the Long-necked Beasts they are simple broad expansions stretching out from each side of the bone like a pair of wings, and more or less throughout its whole length; in the *Giraffe* and Camel-like Beasts these processes are very narrow in the centre, and only expand, towards the ends of the bone, but not reaching the level of the head or cup of the vertebre, so that they do not interfere with the free motions of the Neck; in the *Camels* they are largest, and the lower especially are of considerable size and bend downwards, that of the sixth vertebre resembling a broad hatchet, and having on its outer surface a bony stud indicating a bifurcation of the process. In the other Ruminating Beasts with horns and large heads the transverse processes are all large and long, and their front ends project beyond the vertebral head, as in *Deer* and *Cattle*. In the Short-necked Beasts the transverse processes are longer than the vertebral body, their anterior ends projecting forwards and inwards, the posterior backwards and outwards, so that each bone locks in the one that precedes and that which follows it, and is itself also in like manner locked in; by which structure the dislocation of the vertebral bodies from each other in the violent actions of the Neck is prevented, and lateral motion restricted, though little interfering with the twisting motion. This arrangement is well seen in the *Cat* kind (fig. 9. A.) and other Digitigrade Beasts. In such animals these processes are also generally bifid, the locking portion being above, and a broader portion below for muscular attachment; and that of the sixth vertebre is largest and hatchet-shaped. The size and projection downwards or outwards of the lower part of the transverse process, and the greater or less length of its locking parts, indicate the strength and motive power of the Neck; thus, in the strong-necked *Cat* kind the processes bend down and are well locked; in the *Hedgehog* and other Insectivorous Beasts, as also in the whole Family of Bats, the processes are less large and stretch outwards. In the Monkeys, and also in the *Elephant*, the transverse processes stretch outwards, and are distinct from each other; so also in the Spouting Cetaceans, the Neck vertebres being very short, these processes are somewhat funnel-shaped backwards, and received into one another.

The first two Neck vertebres are distinguished from the rest, as in Birds and Reptiles, by the rotatory motion performed between them, and by all their joint-surfaces being covered with cartilage and enclosed in synovial capsules; they have, however, a general correspondence with the other vertebres of the same region as to length, being long or short as they may be.

The principal peculiarities of the Second or Pivot Vertebre (n.*) relate to the form and size of its pivot (b.) and the development of its spine. The pivot process, springing from the middle of the front end of the body, is generally a simple bony, cylindrical or conical peg, as in the *Cat* kind (fig. 9. n.*), varying in size according to the bulk of the head, equalling in length that of the under part of the ring of the atlas, within which it is received, and having its tip more or less pointed: it usually separates distinctly the anterior articular processes or surfaces which are on the vertebral body itself, and not on the arch, and face more or less forwards, outwards, and upwards; sometimes, however, as in the *Hedgehog*, a narrow articular isthmus beneath the root of the pivot connects these two surfaces, and this in the *Ornithorhynque* (fig. 13. a. a.) becomes a third and distinct articular surface. In the *Piked Whale* there is



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also a distinct pivot, but it is only a low conical stud. In Ruminating Beasts (fig. 2. B.*), and in the *Horse* kind, the pivot (b.) is of great breadth, encircling all that part of the vertebral hole formed by the body of the bone, and in shape not much unlike the vertical section of the hollow cylinder of an eye-glass with its free end rounded: this similarity is increased by the pivot being less thick than the body of the bone, and its base being therefore included in a partial collar or isthmus which connects the lateral articular surfaces for the atlas. The spinous process (i.) is generally of considerable size, rising up more or less high from the whole length of the middle of the vertebral arch, and stretching more or less backwards or forwards beyond it: it is either blunt-ended behind, and slightly overhanging the third vertebre, as in the Carnivorous Beasts, or sharp, well-defined, and more lengthy, as in the Gnawers, especially in the *Porcupine*, *Hystrix*, and *Capybara*, *Hydrochœrus*; in the *Weasel-headed Armadillo* it extends to the fourth, along the front and tip of the spine, to which it is closely affixed,—and this animal is further remarkable for the consolidation into one of the second and third vertebres; in the *Nine-banded Armadillo* (fig. 14. B i.), also, the pivot spine, connected with the third and fourth, overhangs that of the fifth vertebre; in the *Small Bottle-nose Dolphin* it is of considerable length, and reaches like a peak over the spines of the four following vertebres, but in the *Common Dolphin* is bifid; in the *Porpesse* it not only overlaps, but is consolidated with them; in the *Bottle-nose Whale*, *Hyperoodon*, the spines of the second and following four vertebres form together an upright trigonal pyramid, the hinder face of which is hollowed vertically and receives the independent spine of the seventh. The forward projection of the spinous process is most considerable in Plantigrade and Digitigrade Beasts, as in the *Badger*, *Bear*, *Dogs*, and *Cats*, in which it completely overhangs the arch of the atlas; in many Marsupial Animals, as the *Kanguroos*, it is very similar, but projects less in the Insect-eaters, and little or not at all, with few exceptions, in the Gnawers; in the *Armadillos* it seems to articulate with the arch of the Atlas, but in the *Pangolins* and *Ant-eaters* it is longer and free; in the *Piked Whale*, *Balænoptera*, it curves forward over the atlas blunt, but deep and compressed. In *Ruminant* Beasts (fig. 2. B.* i.) the spinous process is low; it is deepest and thickest in those with heavy horned heads, as *Cattle*, *Deer*, &c., and if longer than the vertebral arch projects only in front; but in those without horns, as the *Giraffe* and *Camels*, &c., is low and sharp; in the *Horse* kind it is sharp in front, but widens and deepens behind. In the *Monkey* Family in general the spinous process is pretty long and empressed; but in the *Orangs* it is comparatively less long, reclined, and bifid. The transverse processes (g.) are usually short, but there are a few remarkable exceptions: in the *Ornithorhynque* (fig. 13. B.) they are very long, of an oval paddle-shape, perforated each by a very large hole, and, reclining, cover those of the two subsequent vertebres; they are also remarkable for their terminal half being joined to the radical portion by a ligamentous joint. In the *Piked Whale* the transverse processes are of considerable size, and greatly resemble in form, extent, and disposition those of the *Ornithorhynque*. From the distinct development of these processes in the *Piked Whale* it becomes questionable whether in the *Dolphins*, which have the first three vertebres consolidated, in the *Hyperoodon*, which have the first six, and the *Porpesses*, which have all the Neck vertebres in a single mass, the large outstretching conical transverse processes in front of those of the third vertebre do not really belong to the second, rather than to the first or atlas, as generally believed. In Ruminant Beasts, and in the *Horse* kind, the transverse processes of the pivot vertebre differ only in being smaller.



The Atlas, or First Neck vertebre (A.*), is almost invariably an oval bony ring: its under part consisting of a slightly curved transverse band, the only analogue of vertebral body; the upper part or arch, of a second transverse band, more or less arched circularly or angularly; and the extremities of these bands terminating in small blocks, on the front of which are the articular sockets for the condyles of the skull, on the back the articular surfaces for those on the body of the pivot vertebre, and on the outer side of each the outstanding transverse processes. Of the large aperture contained within the ring, the upper part only is the hole for the spinal marrow; the lower portion, included between the lower band and an imaginary line stretched from the lower edge of one to the other front articular process, and in all the other vertebres occupied by the mass of the body, being here the hollow in which is lodged the pivot of the subsequent vertebre. In the Monkey Family the body and the arch of this vertebre are connected pretty equally with the articular blocks, of which the front sockets hollowed from above downwards, and from side to side, face forwards and inwards, and the hind nearly plane joint-surfaces look backwards and inwards; the length of the body is greater than that of the arch; and the transverse processes very small, especially in the *Orang* and *Chimpanzee*, and little larger in the *Mandril*, are of triangular form, with their point outwards, and flattened from before to behind. In the *Ornithorhynque* (fig. 13. A.*), however, is the body (a.) of greatest length, and remarkable not only for a mesial longitudinal ridge, but also for two lengthy processes (p. p.) which stretch back from its hinder edge, beneath the body of the pivot vertebre. But in all other Beasts the arch is longer than the body, which seems to connect only the front articular processes, as the former more particularly connects those behind. In many of the Gnawers the arch is little longer than the body, but in the Plantigrade and Digitigrade Beasts it is very considerably longer, as in the *Badger*, *Cat*, and *Dog* kinds. In the *Ichneumon* the middle of the body is little more than a bony thread, which widens at its connexion with the front articular sockets; but in the *Kanguroos*, *Wombat* (fig. 17.), and some other *Marsupial* Beasts, the body (a.) is actually deficient in the middle. In the Plantigrade and Digitigrade Tribes the vertebral canal is considerably exposed between the arch and the skull by the lengthening forwards of the roots of the sockets for the condyles of the latter, so that on the under surface of the bone they are completely distinct from the transverse processes, as in the *Bears*, *Cats*, and *Dogs*. But in the *Seals* the reverse occurs, the vertebral canal being open between the atlas and pivot vertebres, and the arch of the former projected so far forwards as to be anterior to the front end of its body, terminating in a thick blunt edge, and having beneath its outer edges the articular sockets for the



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condyles of the skull concave from before backwards, and facing directly downwards, consequently their plane is at a right angle with the hind articular surfaces. In the *Mole*, also, the front of the arch projects much, and laps over the edge of the great occipital hole. The arch of the Atlas is almost invariably unprovided with any spine, but, excepting the *Three-toed Sloth*, it exists in the Edentate Order, as a small stud in the *Four-toed Ant-eater*, and increasing in size in the *Short-tailed Pangolin* and the *Nine-banded Armadillo*; it is also discernible in the *Echidna* and in the *Ornithorhynque*, projecting slightly above the occipital hole; and in the *Piked Whale* is still more developed. The most remarkable character, however, of this vertebre is the large size of its transverse processes, which, except in the *Piked Whale*, and perhaps in all the other Spouting Cetaceans, are larger and further outstretched than those of any other Neck vertebre. In the Monkey Family they are least outstretched, especially in the *Orangs*; of a conical form, and compressed from before to behind. But in the Plantigrade and Digitigrade Tribes they are flat, face downwards and forwards, spread widely outwards and are also extended backwards along the sides of the body of the pivot vertebre; their roots are principally connected to the arch and to the sides of the hind articular surfaces, and scarcely reach the bases of the front articular sockets, as may be observed in the *Bears*, *Cats*, *Dogs*, &c. The Gnawers have generally the same form and disposition of these processes, but they are of smaller size; in some of this Order, however, their plane is vertical; they face also forwards and outwards, and are deep and lengthy, as in the *Jerboa*, *Dipus*, and more especially in the *Coypu Rat*, *Myopotamus*; and in others, as the *Marmot*, they are horizontal. In the Ruminant Beasts the transverse processes are of much smaller size, commence by a sharp edge from the front edge of the articular sockets, are continued along each side of the vertebral body, widening as they pass backwards, but scarcely extend behind the edge of the hind articular surfaces, and much resemble those of the other Neck vertebres. In the *Horse* kind they are short and rounded, like the end of a spatula, and horizontal. In the *Nine-banded Armadillo* they scarcely exist, and the sides of the Atlas form a long plane surface (fig. 4. A.* g.), the only indication of transverse processes being a little lip on each side, which closely embraces the front end of the first vertebre. In the *Manatee* and *Dugong* they are short, stout, and blunt, but in the *Piked Whale* triangular, flattened from before to behind, and vertical.

A very few instances occur in which two or three Neck vertebres are rather partially or wholly connected by bone to form a single piece; in the *Porpesse*, in the *Common Dolphin*, *Whale*, and *Narwhal*, the atlas and pivot vertebres only are anchylosed; but in the *Bottle-nosed Dolphin* the following bone is connected with them; and in the *Bottle-nosed Whale*, *Hyperoodon*, the first five are completely connected, and the upper part of the body of the fifth, with the corresponding part of the seventh, leaving a gap below into which the wedge-shaped body, the only part distinguishable of the sixth, is received. In the *Nine-banded Armadillo* the second and third vertebres are united by both bodies and spines, and in the *Weasel-headed* species, the second, third, and fourth, but by their spines only.

*The Back.*—The number of vertebres in this region (a) is generally from twelve to fourteen, though in several instances it extends to eighteen or twenty, and in one Beast alone, the *Unau*, to twenty-four; in a few examples there are but eleven, and in one alone, the *Nine-banded Armadillo*, ten vertebres; and it is further remarkable that these two extremes should occur in the same Order, viz., the Edentate. As to the general number in the various Orders, the Thick-skinned has most, varying from thirteen in the *Babiroussa* to twenty in the *Elephant*; whilst, on the contrary, the Wing-handed has fewest, descending from thirteen in the *Roussettes* to eleven in the greater number of English *Bats*. The bodies of the Back vertebres are, excepting in Long-necked Beasts, of greater length than in the other parts of the Spine, of greater depth, and compressed on the sides; their ends are nearly flat, and the larger number have on each side, and cutting into the edge of each end, a little hollow or half cup, which, with those on the adjoining vertebres before and behind, form shallow sockets for the heads of ribs; but sometimes the sockets are perfected by single vertebres, as those for the first pair of ribs always on the first Back vertebre alone, and in some Orders, as the Sarcophagous, those also for the hindmost two, three, or four pairs on the corresponding vertebres; whilst on the contrary, in Ruminating Beasts, the sockets for all except the first pair of ribs are formed by two vertebres. In the Spouting Cetaceans the number of vertebral bodies having articular sockets are few, and each pair perfected by a single vertebre; thus, in the *Porpesse* there are six; in the *Bottle-nosed Dolphin* five, and in the *Common Dolphin* only four. The transverse processes are not bifid, but each has on the under surface of its tip a flattened articular surface for connexion with the tubercle of the corresponding rib. Sometimes, but not always, the transverse processes lengthen proportionally to the backward position of the vertebre; those in front stretch directly outwards, but the hinder stretch either outwards, backwards, or even forwards, in correspondence with the direction of the spinous processes. The transverse processes of the Spouting Cetacean Family, as the *Porpesse* (fig. 18. g.), are very remarkable for their great lateral extent; they are very broad from before to behind, very thin, and stretch out from the vertebral bodies on the same plane as the floor of the vertebral canal, and all have articular surfaces for the ribs, to which, excepting the first four in the *Common Dolphin*, the first five in the *Bottle-nosed Dolphin*, and the first six in the *Porpesse*, they alone afford connexion. The vertebral arch varies as to breadth and elevation: if wide, it is flat, as in the *Bats*, but as it narrows it gradually rises more and more, so that in Ruminating Beasts it is elevated like a ridged roof, from the ridge of which springs up the spinous process. Generally the vertebral canal is deepened by the roots of the transverse processes being interposed between the body and the arch, but in the *Porpesse* and others of its Family, those processes projecting from the vertebral body itself, the two sides of the arch at once spring up, and, approaching each other to produce the spinous process, give the vertebral canal a trigonal, instead of its usual irregular pentagonal form. The spinous processes vary considerably in length and strength in proportion to the length of the neck, or the weight of the head, or the power of its vertical motion; thus, in all the Long-necked Beasts, these processes, or *withers*, as they are vulgarly called, are very long, as in the *Camel*, in which the first eight are of equal length, broad below, rising up, and slightly reclining, of a com-

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pressed triangular shape, with the sharp edge in front and the base behind, hollowed vertically to lock on the front edge of the following spine, flattened on the sides and its tip, excepting that of the first, swelling and blunt; the ninth and following three spinous processes shorten successively. In the *Giraffe* the first spine is a little shorter than the next three, which are equal and of considerable length, and behind these the rest gradually shorten. In the *Horse* kind the first spine is very short, pointed, and curves backwards, the second longer and nearly vertical, the following four longest and much reclined, behind which they diminish in length to the fourteenth, which, with the remaining four, is of equal height and stoutness, become wider from before backwards, and are more upright, or even incline forwards. In *Cattle* which, although their neck is short, have heavy horned heads, the first spine is short, the following four equal and of great length, and thence backwards they diminish in height. In consonance, also, with the heavy heads of the *Swine* (fig. 3. B.), *Tapiir*, *Rhinoceros*, and *Hippopotamus*, the first three spines are equal, of great length, and the second the stoutest. In Carnivorous Beasts (fig. 9. B.) generally, the first spinous process is lengthy and tallest of all, and from it those following successively shorten to the tenth, eleventh, or twelfth, which is shortest; and towards this they recline more and more, the front ones being nearly upright, but free, and not interlocking. In the *Cat* and *Weasel* kinds these processes are slender and somewhat pointed, but in the *Dogs* and *Badgers* stouter, and swelling at their tips. The shortest spine is remarkably characterized by its nearly rectangular form, its front edge rising vertically from the front of the vertebral arch, and resting against the back of the preceding spine, and thus rendering both nearly or entirely motionless, as in the *Dog* and *Badger* kinds; but in the *Cats*, which have remarkable flexibility in the Back, this spine is low, and nearly an equilateral triangle, so that the last reclining and the first proclining spine arch over it, but with such space as to allow this part of the Spine, when at rest, to be sunk below the ordinary level of the Spine in Beasts, and thus lengthen, by the hollowing above of the spinal column, its extent of flexion, and thereby increasing more powerfully its spring. The vertebral arch also lengthens behind the root of the spine, rendering the articular processes more free and distinct from the roots of the spinous, beneath which, on the vertebres in front, they are situated. In correspondence with this backward lengthening of the arch, it becomes wider and wider in each successive vertebre to the loins; the hinder articular processes face more and more outwards and downwards, each assuming the form of a vertical section of a short cylinder which lies horizontally in the corresponding concave front articular process of the next following vertebre, this allows the free flexion and extension of the Spine in galloping, which is the frequent pace performed by animals of this Family, and principally effected, so far at least as the Spine is concerned, in the hinder part of the Back and the fore part of the loins. The succeeding spines again lengthen and widen from before backwards till they reach the loins, and incline more and more forwards, the front edge of their root locking into a cleft between the hind articular processes of the preceding vertebre. In the Gnawers the spines are tolerably lengthy, though not very strong; and among them, in the *Rats*, the second spine is of considerable length, and sometimes further lengthened by an auxiliary piece at its tip; whilst in the *Porcupine* the first is very large and long. In the *Kanguroos*, *Kanguroo Rats*, *Dasyures*, *Wombat*, and *Myrmecobius*, the first spine is longest and reclines, and those following shorten, become more upright, and are wider from before to behind. In the *Ornithorhynque* the first spine is rather longer than the last of the neck, but not longer than the others belonging to the Back vertebres, and all recline except the last two, which become more and more upright like those of the loins. In the *Echidna* all the spines are low and recline. Among Insect-eating Beasts, the spines, which are low in the *Hedgehog*, are reduced to mere tubercles in the *Mole*, and throughout the whole Order of Bats are scarcely discernible. In the true Flesh-eating Family, the whole Tribe of *Seals* (fig. 8. B.) have the vertebral arches very wide laterally, and narrow from before backwards, with very short spines, so as to admit very free motion. And the Grazing Cetaceans, as the *Manatee* and *Dugong* (fig. 1. B.), have their spines also short, stout, and upright. The Family of Monkeys (fig. 12. B.) generally have their spines long, slender, and nearly straight; but in the *Orang*, *Chimpanzee*, *Gibbon*, and *Mandril*, the upper two or three only are straight, and the rest recline much backwards, and are shorter than those of the neck, except in the *Mandril*, in which they are longer. In Beasts which largely bend and extend the Spine in their ordinary leaping and bounding motions, the articular and transverse processes are much developed on the hinder Back vertebres, but still more on those of the loins, in describing which these points will be specially considered. But the *Spouting Cetaceans* have a very remarkable arrangement of their articular processes which at first sight are scarcely recognizable as such; for after those of the sixth or seventh vertebre posterior articular processes do not exist, nor does the hind edge of the arch of one vertebre overlap that of the subsequent one; but the anterior processes project at first like short, blunt plates from the front edge of each arch, near the body of the vertebre, and, increasing in length, those of the eighth or ninth vertebre embrace the sides of the preceding arch, and continue lengthening on each subsequent arch, but springing at a greater height from the vertebral body till the spinous processes themselves are embraced by these processes, as is well seen in the *Common Dolphin* and *Porpesse* (fig. 18. C.), in which this disposition continues backwards throughout the greater part of the Spine. In the *Dugong* an indication of this embracing of the spines appears on the seventeenth Back vertebre; but in the *Manatee* it is less discernible, the anterior articular processes of the nineteenth vertebre only abutting against the arch of that before it, and itself similarly circumstanced in regard to the first lumbar.

The *Loins* generally consist of six vertebres (C.), but vary between five and seven; in a few instances among the Edentate, Monotrematous, and Thick-skinned Orders, there are only three or four, and in the first two still fewer instances of only two vertebres, as in the *Long-tailed Manis* and *Ornithorhynque*. The Cetaceous Order is remarkable for the great variety in the number of their Loin vertebres, the *Common Dolphin* having eighteen, the *Bottle-nose* thirteen, and the *Porpesse* eleven; whilst, on the other hand, the *Manatee* has but one. In all Beasts with hind-limbs, *i. e.*, all except the Cetaceous Order, the Loin vertebres are the largest

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and widest, their transverse processes longest, and the spinous erect or inclined forwards and perfectly distinct from each other; the junction of their bodies is such, in very many, as to permit, especially near the back, considerable motion in almost every direction; but the possibility of displacement from one and the other is guarded against by the peculiar form of the articular processes. The length of the vertebral bodies in this region is greatest in those Beasts which leap or spring, as the *Kanguroos, Jerboas*, and their allied kinds; also the *Hares* and *Squirrels*; among the Ruminating Order, the *Musks, Antelopes*, and *Deer*. In the Digitigrade Flesh-eaters, as the *Cat* and *Dog* kinds, the bodies are less long and still shorter, but wider in the remaining Ruminators, most Gnawers, the Insect-eaters, and the Family of Monkeys. In the Cetaceans the bodies not only are short, but successively diminish in size towards the tail.

The form and connexion of the articular processes vary in accordance with the mobility and strength of the Loins. In those Beasts in which simple, though extensive, flexion is performed in this region, without violent exertion, as in the rolling up of the *Hedgehog*, the articular processes are lengthy, but nearly flat. In others which violently bend and extend the Loins, as in galloping and leaping, the posterior articular surfaces, still nearly flat, are inclined obliquely outwards to correspond with the anterior surfaces of the subsequent vertebre, which are inclined inwards, and prevent the slipping aside of the former; such is seen in the *Cat, Dog*, and others of the same Family. A further prevention to displacement, however, is provided in the sub-articular processes, little pointed projections of varied length, which, springing from the middle of the hinder notches between the articular processes and the body, stretch back across the intervertebral substance more or less on the body of the following vertebre, beneath the following anterior articular process on each side, which is therefore contained in a cleft, from which it cannot escape, even though the Loins are violently bent; these are seen in the *Cat, Dog*, and other Carnivorous Beasts, but they are most distinct in the most powerful and active leapers, as the *Jerboo, Dipus Afer*, and *Kanguroos* (fig. 19. n.). In the Ruminators, and also in the *Horse*, the locking is effected by the posterior articular processes being vertical sections of short cylinders, which are lodged in the correspondently concave anterior processes, as in the *Ox, Sheep*, &c. Most commonly the anterior articular processes of each vertebre have a more or less distinct tubercle on their upper surface, which exists on many of those of the back as well as of the Loins, as in the *Horse*; but sometimes they rise into compressed spines, particularly in the Loins, as in the *Cat* and *Dog* kinds, and many others; but in the *Squirrels* and *Hares* these processes acquire considerable length, and in the *Chlamyphorus* and *Armadillos* (fig. 15. p.) are so long as to have their tips on a level with those of the proper spinous processes. The posterior articular processes in the latter Beasts are also very long and wide, and often have their broad ends slightly forked; in the *Squirrels, Porcupines*, and others, they are long and pointed. The transverse processes are very various in size and direction; in the *Ornithorynque* and *Echidna* they are deficient; in the *Loris* they are very short and little more than studs; in some of the Ruminators, as *Oxen, Sheep*, &c., and also in the *Horse* kind, they stretch directly out from the vertebral arch, are long and flat. In the Spouting Cetaceans they are also flat and horizontal. But in proportion to the strength of the hind limbs they lengthen, curve forwards and incline downwards, as in the *Cat* kind and other Digitigrades; in the *Musks, Deer*, and *Antelopes*; in the *Lemurs*, but still more in the *Squirrels* and *Rabbits*. On the contrary, in the *Monkeys* they are generally, but not always, short; in the *Hedgehog* and other Insect-eaters, and in the *Bears*, still shorter, but shortest in the *Slender Lori, Nycticebus gracilis*. In some few instances more or less of the transverse processes are consolidated together like those of Birds, which occurs in *Cattle*, and sometimes in *Deer* and *Antelopes*, their extremities being extended backwards and forwards till they meet; or their roots are united by articular surfaces, as those of the last two Loin vertebres in the *Horse* kind; or their tips articulate with the rump-bone, as those of the last vertebre in the *Hippopotamus*, of the last two in the *One-horned Rhinoceros* and *Asiatic Tapiir*, and of the last three in the *Two-horned Rhinoceros*. The spinous processes in this region are generally inclined forwards, varying in length and height generally in proportion to the length of the hind limbs. The Spouting Cetaceans, however, are an exception to this rule, their spinous processes being extremely long, although they have no hind limbs, whilst the Grazing Family, which are similarly circumstanced, have their spines low and blunt. The *Hares* are remarkable from their first three loin vertebres being furnished each with a spine on the under surface of the body, of which the second and third are largest, and equal that of the superior or true spines; this character is, according to Meckel, not seen in any other Gnawer.

The *Rump-bone* (o.) consists of more or less vertebres, generally, though not always, consolidated together into a single piece, of which the anterior two or three are always connected by cartilage or bone with the hip-bones, and one or two of the posterior with the haunch-bones, either, as most usually, by the interposition of strong ligamentous bands, or, as in but few instances, by an immediate cartilaginous or bony union, as in the *Armadillos, Pangolins, Ant-eaters*, and some of the *Musks*: in either case, the junction of the Rump-bone with the hip and haunch-bones, assists in forming the hip-girdle. Generally the width of the first and second of these vertebral pieces, including their transverse processes, is greater than that of the subsequent pieces, which diminish in all their proportions from the fore to the hindmost, and more especially so in those of the Monkey Family, which are either tailless or short-tailed, as the *Orangs, Mandrils*, and others. On the contrary, in those Beasts with powerful tails, as the *Spider Monkeys*, the *Kanguroos*, and the *Beavers*, the hind vertebres are wider than those in front, and in the *Armadillos* at least as wide again. In those Rump-bones which consist of distinct pieces, the articular processes generally, though not always, exist; and even when the pieces are consolidated into a mass they are still indicated. The transverse processes of all those vertebres which are connected with the hip-bones have their tips expanded more or less vertically into irregular surfaces of various size and shape, upon which are affixed the cartilaginous plates uniting them with corresponding surfaces on the hip-bones; but all the rest, even those which join the haunch-bones, are flattened, except in the *Pangolins* and *Ant-eaters*, in which

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these processes (fig. 16. g.) overhang the haunch-bones, and have their extremities thickened, more especially the latter, in which they become short, blunt, angular knobs. The spinous processes are longest in the Gnawers and in the Toothless Beasts, excepting in the *Sloths*, in which they are scarcely discernible; so also in the *Loris*: they are very low in the tailless and short-tailed kinds, and among the Monkey Family; in the Predacious and Ruminant Beasts they are generally well marked. Sometimes, when several vertebres are consolidated, they appear, however, as distinct processes, as in the *Horse*; at other times distinct, but with their tips connected by a bony fillet, as in Ruminant Beasts, and in the *Beaver*, &c.; and in some instances they are so entirely massed together as to form a lengthy keel, as in the *Mole*.

The *Tail* (E.) varies considerably in regard to length: in some instances, as in the *Orangs* and *Chimpanzee*, in the *Slow Lori*, in several of the *Roussettes*, *Phyllostomes*, and other of the Bats, it is so short as not to project the tegument of the hind part of the trunk, and therefore such Beasts are said to be tailless. On the contrary, in the Cetaceous Order, more especially, also, in the *Spider Monkeys* and several others of the same Family, in the *Kanguroos*, in the *Jerboas*, *Squirrels*, and in the Toothless Order, excepting the *Sloths*, it exceeds the length of the trunk and head. In the Digitigrade Carnivorous Beasts it is also long, and in some of the Gnawers, but in many of the latter is short. In the Thick-skinned Beasts, excepting the *Elephants*, it is short; in the Ruminant Order it is shortest in the *Musks* and *Goats*, longest in the *Antelopes* and *Cattle*, though not in either of considerable length. Generally the bodies of the Tail vertebres diminish in girth, and increase proportionally in length from the root of the tail to the tip; but the Cetaceous Beasts form an exception to this rule, as in them the hindmost Tail vertebres have greater proportional width than those in front. When many of the rump vertebres are massed together into one, and, as usually happens, their body and arch are depressed, the neighbouring Tail vertebres are also depressed, and their arches low, as in *Cattle*, *Sheep*, and other Ruminant Beasts, also in the Digitigrade and Plantigrade Predacious Tribes, and in the Tailless and Short-tailed Monkeys. In the Long-tailed Toothless Beasts, however, as the *Ant-eaters*, *Pangolins*, &c., the arch is lofty and of a squarish shape, with its articular processes on the upper angles and far above the body. In such as have all the rump vertebres distinct, as the *Squirrels*, *Jerboas*, *Kanguroos*, &c., the front Tail vertebres are only distinguished by their smaller size. The length of the spinous processes varies considerably; but, as a general rule, the front spines are deepest when the tail is lengthy, and low when the contrary; the tail spines of the *Porpesse* and other Spouting Cetaceans, and those of the Edentate Order, excepting the *Sloths*, exhibit the most striking instances of the former—those of the Tailless and Short-tailed Monkeys of the latter; but commonly when the tail is long the front spines have not great depth. In only a few of the front Tail vertebres are the vertebral arches and spines perfect, consequently the vertebral canal ceases at the point of their subsidence, and a slight longitudinal grove upon the upper face of the tail, running between the roots of the anterior articular processes, now converted into simple studs, and unconnected with the preceding vertebres, of which the posterior articular processes are smaller studs, alone indicates its position. The transverse processes of the front Tail vertebres are depressed, generally largest and longest, and gradually diminishing in size as they recede from the trunk, till they subside into mere ridges, and thence to the tip of the tail cease to exist. In some few instances, however, as in the *Beaver* and in the *Ornithorhynque*, the tranverse processes lengthen from the root to the middle of the tail, and thence shorten to its tip. Inferior spinous processes exist in most long-tailed Beasts, consisting of V-shaped bones, each attached upon the intervertebral substance and corresponding ends of the adjoining two vertebres which it connects; the number of these loose spines varies considerably: they are most numerous in the long-tailed Toothless Beasts, as the *Ant-eaters*, *Pangolins*, and in the Cetaceous Order, in all which they exist nearly to the extremity of the tail; in the *Kanguroos*, *Jerboas*, and *Squirrels*, and also in the *Beavers* they are numerous, but do not extend so far back; whilst in the Long-tailed Monkeys only three or four of the front vertebres are furnished with them. The *Porcupine*, which has a short tail, is remarkable for the two or three front vertebres being provided with inferior spines, and the *Ornithorhynque* for its numerous inferior spines, being processes of the bones themselves, and not distinct pieces.

### 2.—Of the Head.

The several Orders of Beasts, for the most part, exhibit peculiarities in the form of the Head dependent on the shape and relative size and position of the skull and face. The most remarkable of these differences, with few exceptions, are presented in the face, and depend on the form of the jaws, which is always relative to the teeth implanted in them, and these together indicate so distinctly the habits of the animal as to become extremely important auxiliaries in determining the particular order to which any individual belongs. The variety in the form of the skull also not unfrequently depends on the size and motions of the lower jaw upon it, from which circumstance also the kind of jaws possessed by an animal, and consequently its habits, may be determined.

The Skull either projects before and in nearly the same plane with the spine, as in the Cetaceous Order; or it rests upon and at right angle with the spine, as in the Monkey Family; but most commonly it holds an intermediate position, and projects forwards and downwards, as in the Digitigrade, Ruminant, and many other Beasts. It therefore becomes rather difficult to put the Skull, and consequently the whole Head, in its proper position after removal from the spine; but this may be effected pretty certainly by placing the Head so that the plane of the hind edges of the pterygoid processes of the sphenoid bone shall be vertical, which brings the Head into its true relative situation in reference to the neck; but its actual position in relation to the trunk depends on the varying curves which the neck itself is capable of assuming.

(A.) Cetaceans.—This Order exhibits two forms of Skulls—one specially characteristic of one of its Families, and the other having a general resemblance to the form which exists in most Beasts: the former occurs in the Spouting, and the latter in the Grazing Cetaceans.

(*) The Spouting Family, which includes the Porpesse-like and Whale-like Tribes, have the Skull principally

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formed by the occipital and frontal bones, of an oval shape, with its long axis transverse, and its hind and front convexities nearly equal, though the latter is not always observable till after the removal of the face-bones; upon the crown is a prominent knob from whence curves backwards and downwards on either side a ridge which descends as far as the middle of an indistinct ridge curving from behind forwards on each side of the lower part of the Skull, and bounding the temporal pits. The under surface is deeply hollowed transversely, and bounded in front by the lower apertures of the blow-holes, which ascend between the Skull and face to open below the forehead; it is also crossed by a suture marking the separation of the body of the sphenoid bone, as in most Beasts, into two portions, of which the hinder large one consolidates early with the occipital, and the front one with the ethmoid bone.*

The basilar part or process (a.) of the Occipital bone (Skelet. Pl. V., figs. 1. & 2. A.), continued forwards from the lower edge of the occipital hole to its junction with the body of the sphenoid, which is marked on the upper surface by a transverse ridge, is thin and wide behind, but narrows in front by the descent of its side edges to form a pair of deep broad wings (a.*), concave externally, and lodging the greater part of the petrous bones. The occipital part (b.) has below and in the middle the occipital hole (c.), facing backwards and a little upwards, with the broad well-defined though not prominent condyles (d. d.) on each side facing backwards and a little outwards, convex from above downwards and from side to side; from these the articular pieces stretch outwards and forwards, forming a pair of broad wings (e. e) at right angles with those of the basilar piece, and separated from its back by a deep narrow notch; these form pits in front to lodge the mastoid processes of the temporal bones, and seem indications of the paramastoid processes, hereafter to be described. Continuous upwards from these, and the upper margin of the occipital hole, the bone rises convex behind and concave in front, like a clam-shell, assuming an angular form, of which the blunt projecting point is received into a corresponding cleft in the middle of the hind margin of the frontal bone, with which it here early consolidates, and separates the pointed extremities of the parietal bones from each other. Behind this blunt angle is a little triangular space (g.), the crown of the Skull, formed by the Occipital bone alone, and bounded behind by the transverse ridge (h.) which runs into the edges of the bone. The front cavity of the entire bone forming the back of the Skull cavity is traversed a little above the occipital hole by a grooved transverse ridge, lodging the lateral sinuses, and projecting from its middle a short triangular pyramidal process indicating the rudimental bony tentorium, from the upper angle of which a longitudinal grooved ridge is continued to the upper edge of the bone for the longitudinal sinus. The shallow pits above the transverse ridge lodge the hind lobes of the cerebrum, and the deep ones below almost entirely in front of the occipital hole, the lobes of the cerebellum, separated, however, by a wide shallow cavity on the basilar piece, in which rests the medulla oblongata and pons Varolii, a slight transverse ridge marking the extent of the two latter portions of the nervous mass.

* The general description of the Bones of the Head is from the *Porpoise*, except where otherwise expressed. In fig. 1. part of the Face-Bones have been removed to show the parts beneath.

The Occipito-sphenoidal portion (a.) of the Sphenoidal bone (figs. 1. & 2.) has its body or middle part (i.) thicker than the basilar process of the occipital, with which it is continuous; its front is rough for cartilaginous junction with the ethmoido-sphenoid; its upper surface, slightly hollowed, forms the Turkish saddle, bounded behind by the transverse ridge or posterior clinoid process. From each side of the body stretch out the triangular temporal plates (j. j.), with their truncated external angles beneath the frontal and parietal bones, and externally appearing in the temporal pit; their hinder edge assists in forming the hole in which the petrous bone is contained, and is deeply notched to perfect with the parietal bone the anterior lacerated basal hole; their front edges straight to join the transverse spinous processes of the ethmoido-sphenoid bone: a rough surface beneath marks on each side the boundary between the body and these temporal plates, and here are detached the pterygoid processes and the base of the ploughshare bone. The Ethmoido-sphenoidal portion (B.*) of the bone curves forwards and upwards to join the ethmoid, marked on the upper surface by an indistinct cleft; it forms the front of the base of the Skull, lodges the anterior lobes of the cerebrum, and has on each side a short transverse spine overhanging the optic hole; from the fore and under part projects a thick triangular vertical azygos process (k.), which joins in front the nasal processes of the upper jaw-bones, and forms the partition between the blow-holes; its upper angle is intimately connected with the nasal processes of the ethmoid, and no separation between them is discernible; its lower edge forms a thick rounded keel, which is lodged in the grooved base of the ploughshare bone, and each side is hollowed from behind forwards to assist in forming the blow-holes. The pterygoid processes (a.* *), of which there are only a pair, and those corresponding to the inner, are a distinct pair of bones, joining by their upper edge with the under surface of both portions of the Sphenoid itself; they are lengthy and thin, concave from above downwards and inwards, their hinder end joining the front of the wing-like parts of the basilar piece of the occipital, and their anterior extremity rising upwards and lining that part of the blow-holes formed by the azygos process, has below a deep wide oblique gap, which separates the base of the Skull from the palate. Before this gap an irregularly triangular plate of small size curves upwards and outwards from the lower edge of the principal plates; its hind angle forms the outer and hinder point of the palate, and the front angle is received in a corresponding gap of the palate-bone. The principal apertures in this bone are the small optic holes in its ethmoidal portion, between which and the occipital portion are the lacerated orbitar, and a pair including the oval and round hole on each side in one, and in this piece itself the small spinous holes: between the latter portion and the parietal bones are the large anterior lacerated basal holes, and in the large gap between its temporal plate and the occipital bone on each side lodge the petrous bones.

The Parietal bones (figs. 1. & 2. c. c.*) are of small size, and rest against the front edges of the occipital bone above the paramastoid processes, their largest and irregularly square portion (l.) forming the inner boundaries of the temporal pits: their lower edge on each side stretches from the occipital to the temporal plate of the sphenoid, perfecting with those bones the



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Zoology. petrous gap, and with the latter the anterior lacerated basal hole, and shutting out the squamous portions of the temporal bones from the cavity of the Skull; the outer surface of this part of the bone is deeply striated where overlapped by the squamous plate of the temporal; the upper part lengthens into a long thin process (m.), which curves upwards, forwards, and inwards, corresponding to the edge of the occipital bone, and, narrowing as it rises, terminates in a point before reaching the crown of the Skull, and consequently does not join its fellow; its whole front edge is connected with the frontal bone, and has a correspondent curve. Upon the narrowness of the Parietal bones from behind forwards, and especially of their upper part, depends principally the small lateral extent of the Skull in the *Porpesse* Tribe. But in the *Whalebone Whale* the Parietal bone (figs. 3 & 4.) is considerably larger, and its principal part (l.) resembles a carpenter's rule; the vertical branch descends between the squamous plate of the temporal behind, and the frontal bone in front; and the horizontal branch (m.) is continued above the frontal, separating it from the edge of the occipital, and sends from its fore and upper point the thin process which, running upwards between the front of the occipital and the hind edge of the frontal, ascends to the crown of the Skull, and there joins its fellow.

The Temporal bone (fig. 2. n.) always remains divided into two distinct portions, the squamo-mastoid and the petrous, and sometimes into three, in which case the tympanal cavity is distinct. The squamo-mastoid portion (n.) is very small, the mastoid process (n.) being scarcely developed; the squamous plate is little more so, and is shut out from the cavity of the Skull by the interposition of the parietal bone, against which it laps. The bulk of this portion consists of the projection forwards and slightly outwards of the trigonal glenoid process (n.) to the posterior angular process of the frontal bone; upon its under surface is a long elliptical concave articular surface, facing forwards and downwards for the condyle of the lower jaw, and at the very tip, which is the only analogue of a zygomatic process, it joins the cheek-bone; the pulley for the temporal muscle, between its root above and the squamous plate (p.), is angular, and the whole space between them and the frontal bone, when looked at from behind, is triangular. In the *Whalebone Whale* (fig. 4.) the squamous plate is larger in proportion, but the mastoid process scarcely observable; the glenoid process (p.) is, however, remarkably developed, and has a most striking resemblance to the tympanal bone of Birds, except that it actually forms part of the squamous portion, and juts out from its side to a considerable distance; thence it bends down at nearly a right angle to terminate in a spacious glenoid surface, slightly concave from behind forwards, descending far below the paramastoid process of the occipital bone, between which and its inner edge rests the tympanal cavity of the petrous bone; a blunt triangular pyramidal process juts outwards and forwards to all but touch the posterior angular process of the frontal bone. The petrous portion (n.*) of the Temporal consists of a tympanal and labyrinthic part, of extreme density and weight, and of very irregular figure; the tympanal cavity (q.) is contained in its back and outer part, and the labyrinth (q.*) in the fore and inner; it is lodged in the pit formed by the occipital, sphenoid, and parietal bones, and within the Skull is sunk below their common surface, but externally is seen in the hollow of the paramastoid and wing process of the occipital bone behind, and to the inside of the glennid cavity.

The Frontal bone (figs. 1. & 2. E), prior to the removal of the face-bones, seems to form in the Porpesse tribe but a very small portion of the Skull, the only apparent parts being a knob (r.) in the middle of the forehead, from which a smooth narrow curved band (s. s.) descends on each side in front of the parietal bones, to terminate in the stumpy posterior or outer angular processes (t. t.) bounding the back of the orbit, and to their inner and back part are the small triangular temporal plates (u.). All the rest of the front of the bone is covered by the nose and upper jaw bones, which must be removed to bring it into view, and it will then be found of considerable size. It consists of a large vertical portion, with nearly horizontal broad and long processes projecting from its outer corners. The vertical portion or forehead (s. s. s.* s.*) nearly resembles a pair of widely expanded scallop-shells, set on end, with their cavities facing backwards and slightly inwards, the lower end of the valves being truncated a little below the hinge, and the intervening angle (v.) receiving the ethmoid bone, whilst the hinge analogue itself is completely covered by the nose-bones, and the angle above it receiving the occipital bone, itself projects as a thick knob (r.). Almost the whole convex front surface is deeply grooved for its junction with the nose and upper jaw bones, except on each side of the ethmoidal gap, where it is smooth, the flat plates of the ethmoid bone being here interposed between the frontal and jaw bones, and the lower edge of these smooth surfaces joining the ethmoido-sphenoid bone. The inner surface of the forehead part is slightly marked by the convolutions of the brain, and a mesial grooved ridge lodges the commencement of the longitudinal sinus. The lower margin of the vertical portion divides into a pair of plates on each side; the hinder pair, which are the backward continuations of the same portion, form the triangular temporal plates, which join by their lower ridge and hinder angles with the sphenoid bone, and by their hinder edges with the parietal bone. The front pair, or orbitar plates (w.), stretch forward horizontally in a slightly arched form beneath the upper jaw-bones, to form the vaults of the orbits, with the brow ridges just discernible beneath those bones, bounded behind by the short truncated triangular posterior angular processes (t. t.), which depend to join with the zygomatic processes of the temporal bones, and bounded in front by the anterior flat horizontal anterior angular processes (t.* t.*) which join the lachrymal bones. In the *Whalebone Whale* (fig. 4.) only a narrow transverse band (s. s.) of the Frontal bone is superficial on the forehead, between the face-bones in front and the conjoined parietal and occipital bones behind; but from between these, on each side, stretch outward, downward, and backward the orbitar processes (w.), like the arms of a bow. When separated from the other bones, the frontal part (s.* s.*) of the Frontal bones are found of considerable size, almost entirely covered by the parietal and occipital, and forming the thick squarish handle of the bow. Its hind surface (4.*) is hollowed like the inside of a scallop-shell, truncated about a third above its hinge, and in the middle of the lower edge is a small arched gap (v.), the commencement of a long tube leading forwards on the under surface of the bone to the sieve-like plate of the ethmoid bone. The upper



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surface is disposed in numerous vertical plates, radiating forwards and outwards, which lock in with corresponding plates on the under surface of the parietal bones. From the front project numerous plates of various size, the middle and shortest locking on the back of the nose and muzzle bones, and the outer forming a wedge of plates on each side, run into the pit at the back of each upper jaw-bone. The under and fore part is much hollowed for lodging the ethmoid bone, and to assist in forming the blow-holes. The orbitar processes (w.) forming the vaults of the orbits are so greatly outstretched that they reach beyond the outside of the glenoid processes of the temporal bones, and render the total width of the bone five times so great as the width of the skull cavity. The inner half of their front edge is sharp and scaly, overlapping considerably the upper jaw-bones, but the remainder of this edge only rests against those bones, and the tip forms the anterior angular process. The hinder edge, rounded, terminates in the posterior angular process; and between these angles a short slightly curved rounded edge is the brow ridge or upper margin of the orbit. On the under surface, from each side of the ethmoidal gap, stretches out into each anterior angular process a depending ridge, at its commencement sharp and very deep, but at its termination wide and shallow; this separates the broad concave surface overlapping the upper jaw-bone from the narrow orbitar roof, which is widest at the brow ridge, but narrows and deepens as it runs inwards and backwards, to form with the front of the parietal bone a deep groove, in which lodges the long optic nerve. In consequence of the great length of the orbitar processes, and the projection of the glenoid processes, the temporal pits are remarkably long from within outwards, and narrow from behind forwards.

The Ethmoid bone (figs. 1. r. and 1.*), which completes the cavity of the Skull, exhibits in the Spouting Cetaceans two very remarkable forms. In the Porpesse Tribe it is of nearly pentagonal form, contained within the lower cleft of the frontal bone and the ethmoido-sphenoid bone, with both of which it soon completely unites; it has not any cockscomb within, nor is there any sieve-like plate for the passage of the branches of the olfactory nerves, as those nerves are deficient, but a few very minute apertures transmit some small vessels; in front projects a thick blunt vertical process (x.), consolidated with the azygos process of the sphenoid-bone, and on each side stretch out plates which, in other Beasts, sieve-like, are here solid and broadly and transversely grooved, to form the upper and back part of the blow-holes. In the *Whalebone Whale* proper olfactory nerves exist, and an Ethmoid bone (fig. 3.*), with sieve-like plates, provided for their passage. This discovery was first made and published by Mr. Hunter; and the sections from which his very slight account was drawn up are still in the Museum of the Royal College of Surgeons in London. It is very difficult to give a satisfactory description of the bone from these pieces; but as they are the only subjects attainable for the purpose, an attempt must be made. Of the three specimens, one is marked *Whalebone Whale*, and the other two, one in spirit and the other dry, are called *Piked Whale*; it is quite evident, however, on careful examination, that the wet specimen and the *Whalebone Whale*, so marked, are pieces of the same bone, and, from the shortness of the tube leading to the sieve-like plate, that the species is properly named, for in the *Piked Whale* the tube is of considerable length. The two tubes (α.) diverge as they pass from the cavity of the skull by the ethmoidal gap of the frontal bone, and terminate at the sieve-like plates (β.), which face outwards and downwards (separated from each other by a bony partition). The bone itself seems to consist of a pair of triangular pyramids, of which the bases (γ.) rest against the front of the sphenoid and their tips (δ.), stretching forward beyond the middle of the nose-bones; their under face (ε.) forms the roof of the blow-holes, and the two pyramids themselves, separated from each other by the large cartilaginous nasal plate or partition, which extends from between the front of the nasal tubes forwards and downwards into the gutter of the ploughshare bone, with it separating the blow-holes, and running forwards with it between the muzzle-bones to the snout. Each piece includes a cavity (o. o. o.), which is divided into several compartments by the protrusion from the outer side of the cavity of thick plates (ζ.), and two or three bulbous projections (ζ.*), as if the walls of the cavity had been variously twisted on themselves, and at their conjunction had formed cells, as will be seen in the more highly developed Ethmoid bones. But in these animals the convolutions form no cells, the interspaces being filled with loose cellular bony tissue. Upon the opposite side of the cavity corresponding prominences, though of less size, and hollows of larger size, answer to those already mentioned, so that the space between the opposite surfaces is small; along the inner under edge of each pyramid, between it and the nasal partition, a long cleft (η.) leads to the blow-hole, and admits the water into this the cavity of the nostril.



(**) The Grazing Family

Are distinguished from the Spouting Cetaceans by the lengthened, less elevated, and less wide Skull, by the flatness and greater extent of its crown, by the large size of the temporal pits, by the consolidation into one of the occipital and parietal bones, by the separation of the former from the sphenoid, and by the whole surface of the frontal bone being exposed and not overlapped by the parietal or by the upper jaw bones.

The Occipital bone (A.) in the *Manatee* (Skel. Pl. V., figs. 5. & 6.) and *Dugong* (Pl. IV., fig. 1.) remains divided into a basilar, two articular, and an occipital piece, long after the latter has consolidated into one with the single parietal bone; so that in the adult animal, when the ossification of the several parts of the former is perfected, the two bones usually so described are actually but one, forming the back and a great part of the base, crown, and sides of the hind part of the Skull. In the *Manatee* the occipital hole is oval, with its long axis transverse and its plane facing backwards and a little downwards; but in the *Dugong* it is triangular. The basilar piece is triangular, its thin base behind forms the lower edge of the occipital hole, its hind angles are truncated and join the articular pieces, and its truncated front angle becomes very thick, to join by cartilage with the body of the sphenoid bone; its side edges are concave, assisting to form the large holes in which the petrous bones are seen in the base of the Skull. The horizontal extension, backwards and outwards, of the articular from the basilar pieces form the condyles, which are well defined, especially in the *Dugong*, and are longer and face more downwards than in the *Manatee*, though in both cases facing back-

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wards also. Each piece then spreads upwards and inwards towards its fellow, to form the sides and upper part of the occipital hole, more horizontally in the *Manatee*, and, therefore, the hole is low; and more vertically in the *Dugong*, whence it is high and nearly triangular, but in both their points are separated in the mesial line by a narrow gap, which rises up into the occipital piece. The articulars also spread outwards and downwards, forming the paramastoid processes (e.* e.*), which are divided from the condyles each by a notch, deepest in the *Dugong*, in which these processes, though narrow, depend below the condyles; but in the *Manatee* they are less deep, of considerable width, like those of the *Porpesse*, and assisting to lodge the petrous bone. The occipital piece rises upwards and forwards, irregularly flat to the transverse ridge, which terminates on each side in the temporal ridge, well marked and curved in the *Manatee*, but less distinct and straight in the *Dugong*. The hind surface of the occipital bone does not touch the squamo-mastoid portion of the temporal, from this point down to the paramastoid process, a large gap (x.) being left between them, wider and lower in the *Manatee*, narrower and higher in the *Dugong*, in which part of the petrous bone appears. At the transverse ridge the bone bends suddenly forwards and downwards, and becomes horizontal in the *Manatee* in shape of a narrow transverse band (g.), bounded in front by a shallow groove marking the limit of the true occipital bone; but in the *Dugong* there is not any distinction between it and the parietal.

The vault of the Skull is principally formed by the coronal plate (m.) of the Parietal, continued forward horizontally from the occipital bone, of an irregularly square shape in the *Manatee*, its hinder edge much wider than the front, of which the angles considerably lengthened form a broad gap, receiving the frontal plates of the frontal bone, whilst themselves are continued between the frontal and temporal plates of the latter bone. The side edges, concave and rounded, form the temporal ridges which run back to the occipital; and below these descend, inclining a little outwards, the triangular temporal plates (l. l.), of which the lower truncated tip joins to the temporal plate of the occipito-sphenoid. In the *Dugong* the coronal plate (m.) is wider and more square, its front angles shorter, and the gap wider; the temporal ridges more strongly marked, and the temporal plates square and nearly vertical.

The Sphenoid bone (fig. 6. a.) is in the *Manatee* distinct from the occipital, but remains permanently divided into two portions. The Occipito-Sphenoid (a.) has the body (i.) massive behind to join the occipital bone, and thin in front to join the ethmoido-sphenoid. It has a pair of inner and outer pterygoid plates: the inner pterygoid plates (k. k.) descend at right angles with the body to which they belong, are stout, short, wide, and have the hinder surface vertically grooved near the extremity. The outer pterygoid plates (k. k.), with the temporal plates (j.), form on each side a piece independent of the body, the pterygoid itself vertical, with its broad surface outwards, and joining by its hind edge angularly with the inner pterygoid; so that, together, they form an angular space for the palate-bone. The temporal plate (j.) stretches outward from the root of the pterygoid, joins the glenoid process of the temporal bone behind, assisting to form the gap for the petrous bone, and sends a small square portion into the temporal pit, of which the upper edge joins the parietal and frontal bones, and the inside with the Ethmoido-sphenoid. This second portion of the Sphenoid is of a small size; the analogues of the orbitar plates, instead of occupying the bottom of the orbits, are extremely small, and situated in the temporal pits between the frontal above and the palate-bone below. The optic holes are remarkably small.

The Ethmoid bone in the *Manatee* is triangular with its apex, which is above it, received in a cleft between the frontal bones before and above, and the sphenoid behind and below. The cockscomb is very distinct behind, and the nasal process in front, with a few convoluted plates on each side.

The *Dugong* is distinguished by both portions of the Sphenoid and the Ethmoid being united into a single bone; the temporal plates of the former are more vertical; more of the analogues of the orbitar plates are seen externally, and the optic holes are larger. In the latter the cockscomb is less distinct—a kind of wing stretching out from either of its edges, and overhanging the cribriform plates, so as to produce a triangular canal, at the bottom of which are the holes.

The Frontal bones, a pair (fig. 5. K.), unite by the inner edges of their frontal plates, and form a triangular piece, of which the hinder point (r.) is received in the cleft of the parietal, and the thin base (x.) in front forms the upper margin of the large external nasal aperture. Its side edges, very strongly developed, form the front of the temporal ridges (ρ. ρ.), which, extending as far as the angles of the base, then stretch outwards and forwards, expanding in the *Manatee* to form the top of each orbit and supraciliary ridge with its posterior and anterior angular process (t. t.*), of which the former does not join the malar, but the latter does with the upper jaw bone. From each temporal ridge descends the temporal plate (u.), connected behind with the parietal and below with the sphenoid, ethmoid, palate, and upper jaw bone. In the *Dugong* the frontal surface is narrower, the projection of its front angle nearly straight, and both brow-ridge and angular processes little developed, so that the orbit has only a small bony vaulting. The temporal plates are more vertical.

The Temporal bones (fig. 5. n.), in all their parts, are of very much larger size than in the Spouters. The mastoid portion is distinct, of a lengthened triangular shape, but wider and lower in the *Manatee* than in the *Dugong*. It assists in forming the back of the Skull, but only touches the occipital bone above and below, the petrous bone, occupying the gap in the temporal edge of that bone, being interposed between them. A well-marked ridge continued downwards and outwards from the junction of the occipital and temporal ridges, divides the mastoid from the squamous portion, of which the scaly plate is thin but of good size. The lower edge, immediately before the termination of the ridge, is arched, forming the upper edge of the margin of the tympanal aperture, which is perfected by the suspension of an U-shaped flat bone (σ.); and in front of this stands out the wide process, which is concave beneath to form the glenoid cavity facing downwards, and above forms the broad pulley for the temporal muscle. From its extremity, and at right angle with it, projects forwards the large and massive zygomatic process (v).

The FACE differs remarkably in the two Families of Cetaceans, the Spouters being furnished with a pair of



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bony tubes, spiracles or blow-holes, as they are commonly called, by which they breathe, instead of by nostrils, with which the Grazers, like other Beasts, are provided.

The Spouters are mostly characterized by width, flatness, shallowness, and equal extent of the jaws, and by the weakness of the lower jaw, and in some by the want of symmetry in the two sides of the upper jaw. In others of them the upper jaw forms an enormous arch above the lower, which has great lateral extent.

The Lachrymal bone (figs. 1 & 2. o.), of which, in the Spouters, Cuvier denies the existence, certainly is found in the *Porpesse*, and those nearly allied to it, but it may be doubtful whether the *Whalebone Whale* has it. In the *Porpesse* it is of an irregular squarish form, placed in front of the anterior angular process of the frontal bone, with its upper striated surface as in that bone; is almost completely concealed by the orbitar frontal expansion of the upper jaw-bone, but its outer margin juts out as a blunt flat process at the front of the orbit; its inner edge is jagged where resting against the jaw-bone, and one remarkable peg-like process buries itself in a corresponding cavity of that bone; its smooth under surface has a distinct short backward stretching spine on which the malar bone is received; it has not any groove or hole for the passage of tears to the nostrils, the latter being deficient.

The Malar or Cheek bones (fig. 2. H.) in the *Porpesse* and its like are very long and slender, curving down from the front of the zygomatic process of each temporal bone, and ascending in front to the little process on the under side of each lachrymal bone form the lower margins of the orbits, and giving to them the horizontal lengthened oval form to which the apertures of the eyelids correspond. In the figure of the head of the *Cape Whalebone Whale* given by Cuvier in his *Ossemens fossiles*, Pl. xxv. fig. 5, the Cheek-bone is stout, short, seemingly round, and arched with the concavity upwards towards the orbit, its hinder end concave, resting on the hinder edge of the zygomatic process of the temporal, and its front end joined to the tip of the zygomatic process of the upper jaw-bone.

The Upper Jaw in the Spouters is either flat, and of equal width and correspondent form with the lower jaw, as in the *Porpesse*, *Dolphin*, and the like; or it is for the most part narrower than the lower jaw, and forming a lofty arch above it, so that the edges of both jaws are widely asunder, except at the tip, where they touch, as in the *Whalebone Whale*.

The Upper Jaw-bones in the *Porpesse* (figs. 1. & 2. J.), *Dolphin*, and the like, have their hinder end ($\xi$.) broadly expanded and overlapping both the vertical and horizontal portions of the frontal bones, being also correspondently grooved and striated beneath for their mutual firm connexion; the inner edge of these expansions receive between them the nasal bones, lower down cover the flat plates of the ethmoid, in front of which they curve inwards and forwards, meet each other, and form the outer and front boundary of the upper orifice of the blow-holes. The *Gangetic Dolphin* is remarkable for a large elevated plate which, with its fellow, rises up, Cuvier states, as a roof over the spouting apparatus, the front two-thirds of the plates joining in front, but unconnected behind for the passage of the spouting tube. In *Dale's Bottle-nose Whale*, similar plates rise up from the upper jaw-bone, but more vertically, and therefore, instead of forming a roof, are separated by a deep gutter. The remaining part of the Upper Jaw-bones each consists of a long unequal triangular pyramid, of which the base behind is jagged and indented to join the palate-bone; its upper outer surface ($\psi$.) is slightly rounded, its outer under edge grooved throughout nearly its whole length to lodge the roots of the teeth; its inner upper surface, of great depth behind, is divided into two grooves; the upper longer one extends from before the blow-hole to the very tip of the bone, and lodges the outer edge of the muzzle-bone; and the lower shorter one, scarcely half its length, receives part of the ploughshare bone; the under surface, with its fellow, forms a large part of the palate, connected together immediately in front of the palate-bones, and underlapping both the ploughshare and muzzle bones, but diverging before so as to form a V-shaped cleft, in which the small palatine piece of the former and the palate-plates of the latter bones form the middle and front of the palate; a nearly triangular vertical space before the vertical process of the palate-bone enters the orbit, and is bounded above by the deep holes in which the peg-like processes of the lachrymal bone are received. In the male *Narwhal* the left Upper Jaw-bone is considerably larger than the right, in consequence of the large socket formed between its palatine and facial surfaces for the lodgment of the root of its large and long straight tusk, which extends nearly as far back as the palate, and projects directly in front to the outside of the muzzle-bone. The right jaw also contains a small tusk, but it never protrudes, and remains rudimental. In the female both the tusks continue throughout life concealed in the jaw-bones. In the *Gangetic Dolphin* the Upper Jaw-bones are considerably lengthened, and compressed in front of the elevated roof already mentioned, and give it the form of a beak supporting a double row of teeth not far asunder; hence it has much general resemblance to the beak-like jaw of the *Gavial* described at p. 310. On the contrary, in the *Spermaceti Whale* or *Cachalot* the front of these jaw-bones is very wide, and their palatine surfaces inclining outwards, so that they form a long keel on the roof of the mouth; according to Cuvier they are either unprovided with teeth, or the teeth are very small and scarcely projecting. In the *Whalebone Whales* (fig. 3. and 4. J.) the Upper Jaw-bones differ remarkably from those of other Cetaceans; singly they are L-shaped, but together they form the letter T laid horizontally with all its branches bent down, the stem being formed by the palatine and the arms by the orbitar processes. The angular junction of these processes on each bone forms the nasal process ($\lambda$.), which rises between the frontal and muzzle-bone; on its inside is a very broad and oblique concavity, assisting to form the blow-hole, and having behind and beneath it a deep pit for the lodgment of the projecting part of the former bone. The orbitar process ($\mu$.), of a lengthened triangular shape, with its base uppermost, curves downward and outwards; half its upper surface is overlapped by the frontal bone, below which the edges only of the bones touch near to the tip of the Jaw-bone, which projects below the frontal, and may be called the malar process; from the rounded front edge of the orbitar a second curved triangular plate ($\nu$.) stretches backwards, terminating externally at the malar and internally at the palatine process, from which it is separated by a deep cleft; it seems to be the analogue of the tuberosity of the bone in more highly developed Beasts; and between it and the orbitar plate is a large triangular pit, which must be the palato-maxillary. The palatine

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process is of considerable length, curving forwards and downwards, separated from its fellow in front by the muzzle-bones, and perhaps also behind by the ploughshare bone; at the back part it is cut out to receive the palate-bone; its inner edge inclines downwards towards its fellow, and together with it and with the palatine, and perhaps with the ploughshare bone, forms a blunt keel extending throughout the whole length of the palate, but rendered in the recent state less apparent from the attachment of the lengthy thick gums in which the whalebone plates are transversely fixed, occupying nearly the whole under surface of the process. The outer surface of the bone being thin in front, gradually deepens as it runs back into the nasal process; its upper edge, sharp in front, but broad and ledged behind, is connected by its whole length to the muzzle-bone.

The Muzzle or Inter-maxillary bones (K.) in the *Porpesse* (fig. 1.) are deep behind, jagged, and connected with the nasal processes of the upper jaw-bones; their upper surface, wide behind, is narrow in front as they project and form the muzzle; the outer surface rests on the upper jaw-bone throughout its whole length; the inner surfaces are applied to each other by the posterior half of their upper edges, forming the roof of a canal, of which the floor is formed by the vomer; upon it a cartilage is lodged which projects onwards to the muzzle, and separates the rest of these edges from each other; the lower edges rest on the edges of the vomer, but soon after the appearance of that bone in the palate the Intermaxillary protrudes between it and the upper maxillary, joins by its inner edge with its fellow, and forms the front of the palate and muzzle. In the *Whalebone Whale* (fig. 4.) the Muzzle-bones are of considerable size, extending from the frontal, between the nasal and superior maxillary bones, along the inner upper edge of the latter, and in front projecting beyond and separating them from each other so as at once to form the muzzle and the front of the palate; their front half is hollowed from above downwards within, and correspondingly, but irregularly, convex without, and the hinder half, which bounds the front and sides of the blow-holes, is somewhat triangular, with the base outwards and upwards.

The Nose-bones (L.) in the *Porpesse* (fig. 1.) form a scutcheon, borne by the frontal bone, between its promontory and the ethmoidal gap, and interposed between the nasal processes of the upper jaw-bones; from their under and fore part a little projecting process juts upon the top of the nasal of the ethmoid. In the *Whalebone Whale* (fig. 3.) the Nose-bones, instead of being borne like scutcheons, are of squarish shape, attached by their hind edge to the frontal, and connected on each side with the muzzle and upper jaw bones; their front edge is free, and bounds the upper and hinder margin of the blow-holes, of which their under surface assists in forming the roof.

The Palate-bones (M.) form the hinder middle part of the palate behind the upper jaw-bones, and assist in forming the fore and under part of the blow-holes. The front of each bone is very much elevated and jagged for its junction with the upper jaw-bone; behind it is concave from side to side, and from above downwards, forming the palatine part of the blow-hole; and below it joins its fellow on the inside, upon the upper surface of which junction is a groove for the lodgment of the keel ridge of the ploughshare bone; the thin vertical plate running back into the orbit, and overlapping that part of the pterygoid piece of the sphenoid bone which bounds the outside of the blow-hole, is the orbitar process, and between this and the palatine process an angular cleft receives the palatine part of the pterygoid piece.



The Ploughshare bone (N.) in the *Porpesse* (figs 1. and 2.) is of considerable size, though mostly concealed by the other bones of the face. Its hinder part is a broad thin plate, underlapping the body of both middle pieces of the sphenoid bone, and stretching across from one to the other pterygoid process; in front of this plate rise upwards and forwards a pair of concave plates, separated by a gap, in which is received the azygos process of the sphenoid and the nasal of the ethmoid bone, the plates themselves fitting into the concavities on the sides of those processes, and thus lining the back and inner part of the blow-holes; the palatine process of the bone projects in front of these plates, of a lengthy triangular form, resting upon the palate and upper jaw bones till the divergence of the latter in front leaves a gap perfected before by the muzzle-bones, in which a diamond-shaped surface of this process appears in the palate.

The Lower Jaw-bone (O.) is most commonly V-shaped; the pair of branches of which it consists being united at an acute angle in front, and diverging behind. Each branch in the *Porpesse* (fig. 2.) consists of two thin plates: the outer plate (a.) extends throughout its whole length, is long and triangular, with its basal edge behind and vertical, of which the thickened upper angle is the coronoid (b.), and the rounded lower the angular process (c.); between these, and rather above the middle, is the small, nearly flat, and irregularly oval condyle (d.) facing backwards, and with its long axis from within outwards; more than half the length of the plate bulges outwards, is very sharp above, and rounded beneath, but the remaining part is shallower and thicker. The inner plate (e.), nearly flat, commences by a forked hind extremity from the upper and lower inner edges of the outer plate, about a third of the bone's length from its base, and, continuing forwards, thickens considerably and forms the lengthy junction of the branches in front; the confluence of the two plates beneath is rounded, but above a long groove is interposed between their edges, in which are lodged the teeth from the front of the bone nearly as far back as the middle; and behind these the plates are so distant from each other, except at their edges, that a long scabbard-like cavity is formed, deficient on the inside from the hind edge of the inner plate. In the *Spermaceti Whale* (Pl. V. fig. 7.) the dental part of this jaw is remarkable for the approximation of its branches, which for more than a third of its length are continued close together to the fore extremity; the massive teeth with which it is furnished incline outwards, so that a sort of angular space is left for the reception of the keel-like palate-bone. In the *Gangetic Dolphin* the branches unite at an acute angle, about one-fourth of the total length from the condyle; thence continue forwards, much compressed, in correspondence with the upper jaw, and near their extremity curve upwards in front of the muzzle. The Lower Jaw of the *Whalebone Whale* (fig. 4.) presents a remarkable contrast to that of the last-named animal, in the width between its horizontal branches by which the comparatively narrow upper jaw is enclosed; each branch curves much forwards from the condyle to its junction with its fellow, is shallow in comparison with its length, and of a triangular pris-

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matic form, but tapering towards the front; its lower rounded edge terminates in a broad blunt angle, and above this, as it were in continuance, is the large wide rounded condyle; the upper sharp edge formed by the junction of both plates (another resemblance to the mandible of Birds) terminates in a thickened blunt edge forming the coronoid process, a little before the condyle, and, the inner plate being continued as far back as this process, a maxillary canal is left between them, which opens by a large aperture beneath the coronoid process.

The Cavities formed by the junction of the Skull and Face bones are the Orbits and Blow-holes. The Orbits are very imperfect; their roof and upper margin are formed by the frontal and lachrymal bones, and by a small part of the upper jaw-bones; but they have not any bony separation from the temporal pits, the frontal orbitar plates not descending on the inside of the posterior angular processes; neither have they any bony floor, the slender cheek-bones forming merely their lower margin.

The Blow-holes or Spiracles are a pair of tubes for the passage of the air to and from the windpipe, and in that function are analogous to the Nostrils of other Beasts; but only in the *Whalebone Whales* do they lead also to the olfactory organ in the ethmoid bone, for in the *Porpesse* and its like that bone is merely a simple plate, with its projecting nasal process separating the Blow-holes, and not containing the organ of scent. Hence there is a difference in the composition and direction of the Blow-holes in the two Tribes, both, however, being partially bony and partially membranous. In the Porpesse tribe the bony portion of the tubes curves upwards and forwards between the skull and face as high as the lower edge of the nose-bones. Their thicker outer walls are formed by the junction of the ethmoido-sphenoid and ethmoid behind, with the nasal processes of the upper jaw-bones in front; and they are divided from each other by the projection of the thin azygos and nasal processes of the former bones to the upper jaw-bones. They are lined by correspondingly shaped very thin tubes, which ultimately are consolidated with them, formed behind and externally by the ascending part of each pterygoid process, and internally by the corresponding parts of the ploughshare bone; below, and to the outside, by that part of the pterygoid processes in front of its gap, and perfected on the inner and fore part by a small portion rising up from the palate-bone on each side. In the *Whalebone Whales* the Blow-holes, in consequence of the width of the nasal process of the ethmoid, and the wide cartilaginous partition, are far apart from each, except at their commencement in the throat, and their termination before the nose-bones, which also assist in their formation. They curve from behind upwards and forwards, at first having the keel of the ploughshare bone on the inner side, the pterygoid processes of the sphenoid, and the palatine and pterygoid processes of the palate-bones below and to the outer side, and the pterygoid processes of the latter curving over above, to join the upper edges of the ploughshare bone, upon which rest the pyramidal pieces of the ethmoid; in front of these resting-places the wide, hollowed-out edges of the ploughshare show that the Blow-holes incline inwards, and probably here it is that the clefts leading to the olfactory organs are placed. The outside of the tubes is formed by the inside of the nasal plates of the upper jaw-bones and of the muzzle-bones, and the roof by the front of the frontal? and by the nasal bones, in front of which they mount upwards, and have attached around them the membranous tubes by which they terminate each by a single external aperture. The difference, therefore, as to the course of the tubes in the two tribes, is, that whilst in the Porpesse tribe they curve regularly forwards and upwards, in the *Whalebone Whales* they curve forwards and upwards, then forwards beneath the nasal bones, and again upwards before them.

The Grazing Cetaceans have their Face remarkably characterized by the greater perfection of their orbits, by the enormous size of their cheek arches, by the existence of true nostrils, by the bulkiness of their muzzle-bones and lower jaw, and by the form of the latter, having a general correspondence in shape with that of all other Beasts, except the Spouters.

The Malar bones (H.) are large, and in the *Manatee* (Pl. V., fig. 5) form more than the under half of the orbits by the inward extension of their concave inner orbitar process, which is largely supported by the upper jaw-bone, upon this also ascends their anterior orbitar process; the posterior orbitar curves upwards towards, but does not reach, the angular process of the frontal bone; the margin of the orbit is therefore deficient. The zygomatic process, deep and square, sends back a long handle-like process beneath the corresponding process of the temporal bone to its glenoid cavity. In the *Dugong* (Pl. IV., fig. 1. 1.* 1.**), the posterior orbitar process not existing, the orbit and temporal pit are confluent; the inner orbitar also is scarcely developed, its only indication being the thick lower edge of the orbit, which lies against, but not upon, the upper jaw-bone, and rises upwards, still thick, as the anterior orbitar process, of which the pointed extremity runs into a pit formed by the frontal bone, and by the nasal processes of the muzzle and upper jaw bones, and its lower margin bounds the top of the large infra-orbitar hole.

The L-shaped Palate-bones (M.) (Pl. IV., fig. 1.**; and Pl. V., fig. 6.) have their stems resting in the clefts between the pterygoid processes of the sphenoid bone; their branches stretch forwards and inwards to meet each other, are received in an angular gap at the back of the palatine processes of the upper jaw-bones, and form the lower edge of the hinder openings of the nostrils.

The Upper Jaw-bones (J.) are deep and long, but not wide; each consists of a lengthy horizontal portion, of which the wide hinder half is indented by alveolar pits for the molar teeth, and the front half is thin and sharp; a narrow thick plate stretches inwards along its whole length, to meet its fellow, and perfect the palate and floor of the nostrils; the hinder upper part rounded, and forming the tuberosity, is in the *Manatee* (Pl. V., fig. 5. & 6.) continued into the pterygoid pit, but less far back in the *Dugong*; the fore and upper part rises upwards and outwards as the nasal process, in close contact with the whole length of the nasal process of the muzzle bone, and joins also the malar, lachrymal, nasal, and frontal bones near the orbit. In the *Manatee* the orbitar process (†.) is remarkable, stretching out from above the front three molar teeth, as a broad flat plate, of which the anterior inner corner ascends to join the nasal process, and with it form the large infra-orbitar hole; a small portion assists in forming the bottom of the floor of the orbit, but the largest part, like a scoop, is continued beneath, and supports the inner and anterior orbitar

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processes of the malar bone. In the *Dugong*, however, the orbitar process itself forms the orbitar floor, abutting against, and not underlapping the malar bone; its front point does not ascend to join the nasal process, though it curves a little upwards, and assists in forming the infra-orbitar hole; the front edge of its palatine portion bends downwards considerably, thins to a sharp edge, and its tip diverges from its fellow.

The Muzzle-bones (K.) are very large, especially in the *Dugong* (fig. 1.), on which they support each a very large bolt-like tooth; but in the *Manatee* these teeth are very small and deciduous at an early period. These dental branches of the bones, long, deep, and compressed, form the front of the upper jaw, stretching beyond the lower in the *Manatee* (fig. 6.), and bending down at a right angle before it in the *Dugong*, much like the beak of the *Flamingo*. In both animals the palatine surface is large, in the *Dugong* especially, and arched transversely, the edges being sharp and depending. From their hinder upper part stretch back the nasal branches, which pass along the fore and inner part of the nasal processes of the upper jaw-bones in the *Manatee* (fig. 5.). They join, to some extent, the inside of the supra-ciliary processes of the frontal bone, and in the *Dugong* also rest on the anterior-orbitar processes of the malar bones. The union of the Muzzle-bones with the frontal recalls their junction with that bone in Birds, with this difference, however, that in the latter the nasal branches, united by their inner edges, run along the mesial line to the forehead, separating the apertures of the nostrils from each other, whilst in Beasts they diverge, and include the nasal openings within them.

The Lachrymal bones (G.) in the *Manatee* are, according to Cuvier, "very small, without any hole, and inserted each in the anterior angle between the frontal, malar, and maxillary bones." In the *Dugong* (fig. 1. & 1.*) they are of larger size, and very distinct between the anterior angular process of the frontal above and the malar bone below, with their inner face resting against that part of the muzzle-bones which form the edge of the nostrils and the roof of the large infra-orbitar hole.

The Nasal bones (L.) in the *Manatee* are about the size and shape of small almonds, placed each on the inner edge of the orbitar process of the frontal, behind the extremity of the muzzle-bones.

The Ploughshare bone (N.) is long and narrow in the *Manatee*, short and wide in the *Dugong* (fig. 1.), and in both is connected by its lower edge to the palate-plates of the upper jaw-bones alone.

The Lower Jaw (O.) has its two sides soon anchylosed, and becomes a single bone; both the horizontal and vertical branch are large and distinctly developed. The rounded base of the jaw in the *Manatee* (Pl. V., fig. 6.) long, and begins to curve a little downwards from opposite the third molar tooth to its symphysis; but in the *Dugong* (Pl. IV., fig. 1.*) is much shorter, and forms a deep curve between the angle and the symphysis. The alveolar edge in the *Manatee* inclines inwards, and supports, in the young subject at least, five grinding teeth; and a little before these the junction of the two edges expand, and form a broad surface, probably covered with a pad of gum correspondent to the palatal expansion of the muzzle-bones. In the *Dugong* the side of the bone is much deeper; its alveolar edge, but little inclined, supports one large and one small molar on each side, in front of which it is sharp to the junction of the branches, when they expand into an irregular oval surface, nearly vertical, to correspond with the muzzle-bones, of a spongy texture, and indented with three pairs of indistinct sockets for lodging teeth; and a little squarish projection, at the lower end of the oval surface, perhaps contains a fourth pair of sockets and teeth. The ascending branch rises vertically, with a little expansion outwards at its termination in the condyle in the *Manatee*, but in the *Dugong* it inclines inwards; consequently, in the former the rounded angle is within the vertical plane of the condyle, but in the latter it is without, and the whole large rounded angle considerably everted. In the *Manatee* the condyle, wide laterally and convex from behind forwards, is but little distinct from the rest of the branch; in the *Dugong* it is very distinct, rather longest from behind forwards, but convex in that direction, and also transversely. The coronoid process is lower in the *Manatee* than in the *Dugong*; in both it is squarish, but in the latter the front edge is more vertical, and the upper angle considerably taller than the condyle.

(B.) RUMINATORS.—This Order has the Skull of small size in comparison with the face, which descends more or less obliquely from its fore and under part. It is generally of short ovate shape, principally depending on the bulging form of the parietal bone or bones which form the vault of the Skull, and its transverse diameter is least. Generally upon the upper and fore part of the frontal bone or bones are a pair of processes, supporting the horns in some kinds and the antlers in others; the horns are permanent; the bony processes or cores defining their shape and length are hollow, and communicate by their large cells with those of the bone itself; the antlers are deciduous, and supported on short processes or burs, of which the interior is filled with cancellated structure. The frontal bone, by the great lengthening of the inside of its orbitar plates, entirely excludes the ethmoid from the orbit.

The Occipital bone (A.) has its basilar process oblong squarish, and very massive; the occipital hole not large, and its upper and lower edges, as it were, receding in consequence of the jutting backwards of the large well-developed condyles, which rise above the level of its upper margin. The condyles are separated by a very deep gap on their outer side from the large and long paramastoid processes; these descend free below the squamo-mastoid parts of the temporal bones, are narrow from within outwards, and wide from behind forwards in the *Ox* (Pl. V., fig. 8.) and *Sheep*, but less lengthy, wider, inclined obliquely inwards, and scarcely independent of the temporal bones, in the *Camel*. The occipital surface is, in the *Ox*, spacious and nearly flat as high as the well-marked semicircular transverse ridge, above the middle third of which a low triangular space inclines a little forwards, and upon its very thick edge (g.) rests the hind broadly-bevelled edge of the frontal bone. This connexion recalls the construction of the Skull in the Spouting Cetaceans, the occipital and frontal bones joining directly together, and the small upper angle of the former being the only indication of the coronal region. Below this, the occipital angle, projects on each side forwards, inwards, and downwards the parietal plates (l. l.) the only analogues of parietal bones; their upper wide edge receives the bevelled side edge of each frontal bone as far as its temporal plate, where it rests in the grooved anterior oblique edge; each lower edge inclining inwards forms a thin scale, received within the squamous plates of the temporal bones. In the *Sheep*

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the ridge is nearly transverse and but little developed, the surface below it rounded from side to side, and the space above not angular, but band-like, and inclining more forwards and downwards has its thick vertical edge deeply toothed to join the coronal part of the parietal bone. In the *Camel* the ridge is more projecting, overhanging, and consisting of two curves meeting in a middle sharp tubercle; below this the bone is narrower than in the *Sheep* or *Ox*, and much more rounded; the space above forms a large triangle, rounded from side to side and curving forward, so that its thick edge is interposed between the hind edges of the two parietal bones. The internal surface of the Occipital bone has no rudimental tentorium, but the boundary of the hollow lodging the cerebellum is indicated by a blunt arched ridge springing up from the sides of the occipital hole.

The Sphenoid bone, divided into two portions, has the posterior portion less early joined with the occipital than the anterior is with the ethmoid bone. The body of the Occipito-sphenoidal portion (s.) resembles a cylinder, bulky in comparison to the size of the bone, hollowed above with a more or less distinct posterior clinoid process; its hind end divides into a pair of bean-shaped surfaces, which descend rather below the cylinder, and unite with the basilar process of the occipital bone. The temporal plates rise up almost vertically from the sides of the body and are very low; in those Ruminators, as the *Sheep* and *Camel*, which have distinct parietal bones, the upper edge is expanded upwards and outwards for the support of those bones, and its outside scale-like to be overlapped by the squamous plate of the temporal; but in such as the *Ox*, of which the parietal is part of the occipital bone, the upper edge is sharp and thin where joining the parietal process, and only broad and indented in front, where it joins the temporal plate of the frontal; its outer surface is also overlapped by the squamous of the temporal, except a small part which appears in the temporal pit. The external pterygoid processes lengthy and thin, broad from behind forwards, are smooth externally, but rough below and within for their junction with the internal pterygoid processes of the Sphenoid and with the palate bones. The Ethmoido-sphenoidal portion (s.*) has the hind end of its body corresponding to that of the Occipital portion, but is compressed in front as the projecting azygos process, which consolidates above with the nasal of the ethmoid, and has stretching from it on each side outwards and forwards, and inclining outwards and downwards, the orbitar plates, lengthened before and on the inside by the triangular plates; a depending trigonal ridge on the under surface of these plates rests between the ploughshare and the palate bone on each side, and their upper surface forms a wide projecting shoot containing the hinder part of the ethmoid bone. Upon the upper surface of the body the anterior clinoid processes stretch out to join the broad roots of the transverse spinous processes, which are connected, in the *Sheep* and *Ox*, by a thick transverse edge, overhanging the olive process, so that the optic holes are situated in the corners of a deep wide pit; in the *Camel* no such overhanging exists. The junction of the roots of the transverse spinous processes forms a large squarish space, bounded in front by its junction with the ethmoid bone, whence they spring up on each side more or less vertically, and increasing in extent from behind forwards to their upper wavy margin. The outer and under surface only of each process appears externally in the temporal pit, the most considerable part being overlapped by and received within a corresponding wide shallow pit on the inside of the frontal bone; the hind upper edge joins the parietal bone as low as a little jutting process, which rests on the jutting front angle of the temporal plate of the Occipito-sphenoid portion, to the inside of which is a broad notch forming the front of the orbitar lacerated hole, perfected behind by a corresponding deep notch in that portion. The internal pterygoid processes (s.**) are distinct bones, thin and flat; in the *Sheep* they are nearly triangular, with their base upwards, lodging in a groove between the body and root of the external process behind; the bone is in close contact with the inner surface of the latter, except its lower angle, which descends below it and curves back like a little hook, and a large part of its front angle, which projects to join the orbitar plate of the Ethmoido-Sphenoid and palate bone. In the *Ox* this process is T-shaped, with a wide stem, of which the hind edge only joins the external pterygoid, so that a gap is left between them in front, which receives the heck of the palate-bone; its hooked process is also less distinct; the bend of the bone has its hind branch long and narrow, resting in the groove before mentioned, but its front branch, short and deep, is continued to the orbitar process of the Ethmoido-sphenoid and palate bone.



Ruminant Beasts exhibit among themselves some remarkable differences in the form and construction of the vault and sides of the Skull. In *Oxen* the vault, as will presently be shown, is formed by the junction of the frontal with the occipital bone, but the sides are bounded by the stretching forward of the parietal plates of the latter bone, as already described; consequently there is no true parietal bone. In other Ruminators, however, there are Parietal bones (c.) forming both vault and sides; either a single one, which rises like an arch from the upper edge of the temporal plates of the sphenoid bone, as in the *Sheep* (Pl. V., fig. 9.); or two, which, springing up from the same bases, unite in the middle line of the Skull by the sagittal suture, as in the *Camel* (ib. fig. 10). The single Parietal of the *Sheep* is divided by the temporal ridges into a middle transverse slightly arched coronal plate, and two lateral temporal plates, which bend downwards and inwards to their junction with the temporal plates of the occipito-sphenoid, and have some resemblance to the corresponding parts in the Grazing Cetaceans by projecting beyond the anterior straight saw-toothed edge of the coronal plate, so that the frontal bones are received within the three; the toothed vertical front edge of each temporal plate joins the orbitar plates of the frontal and ethmoido-sphenoid bones; its smooth oblique hind edge rests against the petrous portion of the temporal, and its outer hinder surface is largely lapped against by the scaly plate of the latter bone, the Parietal itself at this part being correspondently thinned. In the *Camel* the Parietal arch is considerably larger and higher, the temporal plates being much deeper, and bulging considerably outwards from the temporal ridges before their descent to the sphenoid bone, their junction with which is by their shortest ridge. From the hinder end of the sagittal suture the Parietal bones diverging leave an angular gap, in which the upper angle of the occipital is received, and their thick edges splaying up slightly overlap the latter bone; the front edges of the bone curve from the sagittal suture downwards and forwards to the point at which

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the temporal ridge ends, and thence downwards and backwards to the sphenoidal edge, so that a slight angular projection is formed, above which the indented edge joins the frontal part of the frontal bone, and below it the edge becoming scaly laps outside the small temporal plate of that bone and the orbitar plate of the ethmoido-sphenoid; but a small part of the temporal plate is lapped against by the squamous plate of the temporal, which, however, it still shuts out from the interior of the Skull.

The Temporal bones (Pl. V., fig. 8.) each consist of three pieces,—the squamous, the tympanal, and the mastoido-petrosal, easily separable in the young Ruminant Beast, but gradually consolidated into a single bone. The Squamous piece (a.), in the *Ox* and *Sheep*, has its scaly plate long and low, with its straight upper edge inclined outwards, underlapping in the former animal the parietal plate of the occipital bone, and in the latter the parietal bone itself, by which it is excluded from the cavity of the Skull; its under jagged edge rests on the grooved edge of the temporal plate of the occipito-sphenoid, and behind it joins the mastoido-petrosal piece in a ridge, from the under edge of which a little process depends behind the projecting auditory tube in front of the mastoid process. In the *Camel* the scaly plate is larger, more vertical, and has a rounded edge, but still not entering into the inner wall of the Skull. The zygomatic process (a.*) commences sharply from the ridge at the back of the scaly plate, stretches forwards and outwards above the external auditory aperture, and along the outer margin of the glenoid process as an elevated edge, from the front of which it projects free and directly forwards to overlap the zygomatic process of the cheek-bone; in the *Sheep* and *Ox* it is short, but in the *Camel* more lengthy; in the former wide and thin, but in the latter two of a triangular prismatic shape, and thinning towards its tip. The glenoid process, interposed between the back of the zygomatic and the scaly plate, is above the plane of the base of the Skull: its upper surface is triangular, with its base in front, forming the pulley over which the temporal muscle plays; the under or articular surface for the lower jaw is more spacious, particularly in the *Ox* and *Sheep*, extending inwards upon the scaly plate itself, of a squarish form, slightly convex from within outwards and from behind forwards, with the convexity downwards; in the *Camel*, however, it is nearly deeply concave; it is bounded behind by a depending lip, which prevents the condyle of the lower jaw slipping back from the articular surface, of great width, but shorter and more internal in the *Ox* and *Sheep*, of greater length, but narrower and more external in the *Camel*: behind the lip, on the inner side, is the little glenoid hole, and on the outer side the commencement of the jugular canal, which runs backwards and upwards into the pit within the scaly plate lodging the lateral sinus, and has opening into it a hole from above between the zygomatic process and scaly plate. The Tympanal piece (h.) is large, irregular, flattened from behind forwards, and depending considerably below the glenoid process; from its upper outer part projects the external auditory tube (h.*), most distinct in the *Sheep*, and least so in the *Camel*, at the bottom of which a little projecting ring gives attachment to the membrane of the drum, beyond which that cavity hollows the greater part of the Tympanal piece. Below, and to the inner side of the external auditory opening, a deep pit lodges the root of the styloid process, and behind it is the stylo-mastoid hole; from the inner upper part of the drum cavity commences the bony groove forming part of the Eustachian tube, which continues downwards and inwards on the inside of the tympanal piece. The Mastoido-petrosal piece (c.) lies behind the tympanal piece, and is of an irregular triangular form; the hind surface rests against the occipital bone, and with it perfects the back of the Skull; its outer edge unites with the ridge on the back of the squamous piece, and from it depends the little defined mastoid process; the inner upper surface, which forms part of the interior of the Skull, has the apertures for the auditory nerve passing into the labyrinth which occupies the front of this piece, and bounds the cavity of the drum above and within; its lower inner edge perfects with the occipital bone the posterior lacerated basal hole.



The Frontal bones (s.), united by their inner straight edge, form the whole vault of the Skull when the parietal are wanting, as in the *Ox* (fig. 8.); but only the front of that vault when the parietal bone or bones exist, as in the *Sheep* and *Camel*; and thence they stretch forwards to the face, assisting to form the nostrils in front, and on the sides are extended to form the vaults of the orbits. The upper largely expanded frontal plate is, in the *Ox*, nearly flat, with a slight rounding outwards; but in the *Sheep* the hinder half continues on the same plane as the coronal plate of the parietal, as far forwards as the middle of the orbit, where it bends suddenly downwards to the face; and in the *Camel* the hind part curves regularly down to the back of the orbit, and then stretches forward almost horizontally; hence, in this animal the front of the Skull is considerably elevated above the space between the orbits. The hind edge of this plate in the *Ox* is regularly rounded, so that an angular gap is formed by its junction with its fellow, in which the angle of the occipital bone is received; it has also the outer table or shell of the bone extended backwards much further than the inner, rendering the edge itself oblique and very wide, corresponding with the thick edge of the occipital bone, on which it rests. Upon its outer corner rises up the corniferous process or core, like a curved hollow cone, overspread with horn, and its interior filled with numerous air-cells which communicate freely with the frontal cells. Such is the structure of permanent horns, which are also called hollow horns from their internal cellular structure; and of this sort are the horns of *Cattle*, *Sheep*, *Goats*, and *Antelopes*. But the antlers of the *Deer* kind are very different, and are shed annually; their corniferous processes or burs are short, more or less cylindrical, filled up with cancellated structure containing fat and not air, and terminating above in a sort of thick-frilled collar which surrounds the flattened circular extremity; from this the antler annually springs up covered with velvety skin, its interior spongy, and when the growth is perfected, the skin withers, shreds, and leaves the hard bony shell of the antler exposed. The *Cameleopard* is remarkable for having three horns, one on each frontal piece and the other in front of these upon the frontal suture itself; these horns are never shed: they are short, flattened, cylindrical, thin-shelled bones, covered with skin; their upper end is rounded, and the lower spreading out like the foot of a candlestick, and hollowed beneath, rests on a correspondent boss of the frontal bone itself. From each boss the bony horn is easily detached whilst the animal is young, and has not any



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communication with the frontal cells. The outer margin of the frontal plate is bounded by the wavy temporal ridge which runs forwards into the posterior angular process; the hinder half of the ridge is formed by the junction of the overhanging edge of the frontal with the parietal plate of the occipital bone, and the front half by the frontal bone itself, below which descends vertically the temporal plate with its front point pegged into the temporal plate of the sphenoid, its lower and hinder edge resting on the parietal of the occipital, and its lower edge lapped against by the front of the squamous plate of the temporal bone. In the *Sheep* the Frontal has no temporal plate, in consequence of the lengthening of that plate of the parietal which reaches the root of the angular process. In the *Camel*, however, though not large, this plate is distinct; but its lower edge rests on the ledge of the orbitar plate of the ethmoido-sphenoid, and the hinder edges of both are overlapped by the front edge of the parietal. The posterior angular processes in the *Ox* and *Sheep* curve downwards and outwards, separated by a wide gap from the temporal plate; in the former it is flattened from within outwards, and in the latter from before backwards; it forms the hind part of the edge of the orbit, and from it curves upwards, forwards, and inwards, the thin brow ridge or upper orbitar margin, which terminates in the indistinct anterior angular process, just behind which, in the *Sheep*, is a very narrow cleft. From the under surface of the brow ridge, as far back as the root of the posterior angular process, descends the concave orbitar plate, which forms the upper inner and back part of the orbit, to the temporal pit, near to which is a large angular gap filled up by the orbitar plate of the ethmoido-sphenoid. In the *Camel* the roof of the orbit stretches so far out from the forehead, and the gap separating the posterior angular process from the temporal pit is so wide, and the notch in the brow ridge is so large and deep, that it recalls the form of the corresponding part in the *Manatee*. The descent of the orbitar plate, which is really the separation of the inner from the outer table, and which at its lower edge again mounts upwards and inwards to become the inner wall of the cavity of the skull, leaves a large space between that cavity, the orbit and the outer table, which is formed into cells communicating behind with the cores of the horns, and in front with the ethmoidal cells and nostrils, and like them pervaded with air. In the *Ox* and *Camel* the inside of the temporal and the back of the orbitar plate has a wide shallow socket with an overhanging lip in which the orbitar plate of the Ethmoido-sphenoid is received; but in the *Sheep* the socket is only upon the orbitar plate. Opposite a little hole near the lower edge of the orbitar plate a curved thickish ridge stretches from its inside towards the inner margin of the bone, which here becomes of considerable depth, and by its junction with its fellow forms the top and sides of the ethmoidal gap, of which the front bottom is formed by the body of the ethmoido-sphenoid bone; before this the ethmoid bone is placed, an angular depression receiving the top of its cock's-comb, its sides partially covered by the orbitar plates, and its upper surface by the wide nasal processes which occupy all the remaining upper surface of the bone between the orbits, longest in the *Ox* and *Sheep*, but widest in the *Camel*.

The Ethmoid bone (F.) consists of numerous thin plates, some of which are merely twisted, and others coalescing to form cells of various size, which, in the *Ox* (fig. 8.) and *Sheep*, have not very definite form; but in the *Camel* are long quadrangular tubes, wide and open in front, but contracted behind; they are disposed in two sets, and are all connected by their hinder ends to a concave plate perforated like a sieve by their apertures, and hence called the sieve-like plate, through which the olfactory nerves pass to the cells; this plate forms the back of the bone, fills up the gap between the sphenoid and frontal bones, and is divided behind into two regions by the middle ridge or cock's-comb, with its broad expanded top, upon which the roots of the nasal processes of the frontal bone rest; opposite this ridge, in front, descends the nasal plate, which is interposed between the two sets of cells, joined behind to the sphenoid, and before to the cartilaginous partition separating the nostrils. In the *Ox* a pair of thin rounded curving processes rise up, one from each upper outer corner of the sieve-plate, into corresponding cavities on the under surface of the frontal, clamping the two bones together. The upper anterior surface of the convoluted plates is covered by the frontal bones, and their interspaces assist in forming the frontal sinuses; their sides rest against the inside of the orbitar plates of the frontal, which entirely exclude them from the orbits, and their hinder under surface on the orbitar and triangular plates of the ethmoido-sphenoid, in front of which the convolutions project freely into each nostril.

The Face of Ruminant Beasts resembles a four-sided pyramid, of which the base rests against the under and fore part of the skull, and the truncated tip forms the muzzle. The orbits face outwards and a little forwards, their irregularly circular margin is entire, and formed by the frontal, malar, and lachrymal bones, and its hinder and under part especially projects sharply beyond the plane of the cheek; but the back of the cavities themselves are deficient in consequence of the orbitar plate of the frontal and the inner orbitar process of the malar bone being widely separate, and the upper jaw-bone stretching back but little beyond the middle of the orbit; the latter bone is, in the whole Order except in the *Camel*, excluded from the orbit by the lachrymal, which forms the floor. The principal part of the pyramid is occupied by the nostrils and the cavities connected with them; their upper wall is formed by the nasal bones, which do not reach the muzzle, but leave the anterior opening of the nostrils very spacious and oblique in consequence of the lengthiness of the muzzle-bones, which, with the upper jaw-bones, perfect the sides of the nostrils and their floors, except at the hind part, where the palate-bones and the pterygoid processes of the sphenoid assist, and have between them and the body of the latter the posterior apertures of the nostrils. The incisive holes are very large and long. The whole Order, excepting the *Camel-like* Beasts and *Musks*, have in the upper jaw no other than molar teeth; the alveolar processes therefore extend only so far forwards as do those teeth. In the *Musks*, however, there are a pair of very large and long cuspid teeth; and in the *Camel-like* Beasts a pair of short conical cuspid and a pair of incisive teeth. The ascending branches of the lower jaw are of considerable length, but not so long as its horizontal branches, as stated by Pander and D'Alton: its coronoid process is small, thin, and curves back slightly over the small condyle: its molar teeth correspond in extent with those of the upper jaw, and a long, smooth edge, unoccupied, except in the *Camel-like* Beasts, by

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any cuspid teeth, extends between the front molars and the Incisive teeth, six or eight in number, which incline forwards and downwards.

The Malar bones (H.) have their short straight zygomatic process underlapping the corresponding process of the temporal; at its root the short superior orbitar process rises up and joins the posterior angular of the frontal bone, and below it the maxillary process is continued forwards to join the outside of the upper jaw-bone, along which it proceeds, increasing in depth to its junction with the lower edge of the nasal plate of the lachrymal bone, so that in all excepting the *Camel*, the maxillary process is of an irregularly hatchet-like form; its lower edge is inclined inwards and overhung by the upper, especially at the back; and the latter joins by a sharp edge with the inner orbitar plate, of which the width varies, being broadest in the *Camel*, where it joins the upper jaw-bone to form the floor of the orbit, but narrow in the *Sheep*, *Ox*, *Deer*, and most other Ruminant Beasts, in which it joins the lengthy orbitar plate of the lachrymal, and excludes the upper jaw-bone from the orbit.

The Lachrymal bones (O.), except in the *Camel*, are of considerable size (fig. 8.), consisting each of a pair of plates joining together in an angular form by their outer edge, like two sides of a triangular pyramid, and this junction perfecting the orbitar margin between the malar and frontal bones. The hinder or orbitar plate containing the upper aperture of the nasal duct is very delicate, and concave backwards and upwards, forming the floor of the orbit between the frontal and malar bones; it stretches rather beyond the top of the tubercle of the upper jaw-bone, and then curving forwards beneath itself rests upon the latter bone, and forms an ear-like extension backwards of the lachrymo-maxillary cell, of which the outside is overlapped by the malar bone. The front or nasal plate stretches outwards and downwards with the frontal and nasal bones on its upper and the malar and maxillary on its lower edge, and it rests against the side of the ethmoid bone, perfecting its front cells. In the *Camel* (fig. 10 o.) both plates are very small; the orbitar does not form the floor of the orbit, and of the nasal but little is seen externally. All the *Deer* kind (Pl. V., fig. 11.) and many of the *Goats* and *Antelopes* are remarkable for the depression on the nasal plate of this bone, in which is lodged the tear-pit (*.); this is deepest immediately in front of the edge of the orbit which rather overhangs it, as does also the inner edge of the plate which rises vertically in a scroll-like form; in front it gradually subsides on the upper jaw-bone, and on the side extends upon the inner part of the maxillary plate of the malar, which flattens suddenly to assist in its formation. When this pit exists a gap separates the scroll edge of the nasal plate from the nasal bone, so that the front ethmoidal cells are there covered only by fibrous membrane instead of bone. The gap is squarish, as in the *Common Deer*, or long and narrow, as in the *Rein-Deer* and *Elk*. The *Indian Antelope*, *Antelope Oreas*, has no tear-pits, but a long cleft between the lachrymal and nasal bones, of considerable width above, and formed by the incurving of the inner edge of the nasal plate of the former bone.

The Upper Jaw-bones (J.) form the largest part of the Face, its breadth depending on the width of their palatine plates, and its height on the depth of their nasal plates and tooth-sockets, except at the hind part, where the latter depends on the depth of the maxillary part of the cheek-bone, in accordance with the greater or less development of the orbitar plate of the lachrymal bone in the *Ox* and *Camel*. The alveolar or tooth-socket part of the bone is its most bulky portion; it stretches back to terminate in the rounded tuberosity, which generally does not extend behind the front half of the orbit, as in the *Ox* (fig. 8.), *Sheep*, and *Camel*, and in the *Antelopes* scarcely so far: the upper surface of the tubercle generally does not form the floor of the orbit, but lies beneath the lengthened orbitar process of the lachrymal bone; in the *Camel*, however, it does form the orbitar floor; its outer upper part is overlapped by the cheek-bone. The anterior extent of the alveolar process depends on the number of grinding teeth contained in it, and generally it forms about the hinder three-fifths of the lower edge of the bone. The palatine process runs inwards from the root of the alveolar, but is deficient at the hind part to receive the palate-bones within the tuberosities; in front of the molar teeth the palate narrows very considerably, and in front joins the palate branches of the muzzle-bones. The nasal process rises upwards and inwards from the outside of the tooth-sockets to join the nasal bone in front of the lachrymal; and in front of the molar teeth it curves outwards, upwards, and inwards from the palate process to join the nasal branch of the muzzle-bone, its upper edge being curved off obliquely downwards for the purpose of rendering the front of the jaw more slender; the nasal process juts out posteriorly at its junction with the root of the maxillary process of the cheek-bone from the tuberosity, which is therefore separated by a deep cleft from the zygomatic arch; in front it projects beyond the palatine process, and is generally sharp and thin, but, in the *Camel*, a short socket in it lodges the short conical cuspid tooth; so also in the *Muntjak Deer* and in the *Musks* nearly the whole maxillary edge is thickened by the long cuspid socket. The infra-orbitar hole, or front orifice of the so-called triangular canal, which runs from the back of the orbit along the root of the alveolar process, is situated above the first molar tooth. In the large angular space on the inside of the Upper Jaw-bone, between its nasal and palate plates, the ridge of the tooth-sockets is very prominent; below and to its inner side is, except in the *Camel*, the fore and under part of the lachrymo-maxillary cell, which has a large opening into the lower chamber of the Nose, and a concave edge above joining a corresponding edge on the inner and fore part of the lachrymal, and forming the aperture between the different portions of the lachrymo-maxillary cell in each bone; a ridge just below the nasal edge points out the junction of the upper jaw-bone with the turbinated.

The Palate-bones (M.) have their large pterygoid process of considerable size, and stretching far behind their palatine processes, of which the hind edges are separated by a wide V-shaped cleft; the nasal process is little developed, but between it and the maxillary a deep pit in the *Ox* and *Sheep* assists in perfecting the lachrymo-maxillary cell: a very slender orbitar process ascends into the fore and inner part of the orbit.

The Muzzle-bones (K.) are thin and slender; their external or nasal branch runs along the front edge of the nasal process of the upper jaw-bone, corresponds with it in obliquity, and rises up to the nasal bone; from its front extremity stretches inwards the thin flat transverse part of the palatine branch, which forms the



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extremity of the palate, but does not contain any teeth, and extending back from its inner angle a long thin process, which joins its fellow by its whole length, and the palate-plate of the upper jaw-bone by its hind extremity, and leaving between itself and the lower edge of the nasal process the long wide incisive hole. In the *Camel* kind the branches are less lengthy, the front edge thicker and containing teeth, and the incisive holes less large.

The Nose-bones (L.) are narrow and lengthy, form the vault of the nostrils from the frontal bone behind to the front aperture, their outer edge resting on the lachrymal and upper jaw-bones, in the whole Order excepting the *Camels*, in which the nasal process of the frontal separates them from the lachrymal; generally the front extremity is slightly cleft.

The Turbinated bones (P.) are lengthy; a long, narrow, external plate, stretching forwards, connects each bone to the inner and fore part of the corresponding lachrymal, and to the inside of the nasal process of the upper jaw-bone; and from its hind part a bridge crosses inwards to join by its tip to the nasal process of the palate-bone, and define the upper from the lower part of the lachrymo-maxillary cell; from the inside of the lachrymo-maxillary plate a nearly horizontal plate runs inwards to the inner wall of the bone, where it divides into two long plates, both curving from within outwards, the upper downwards and the lower upwards, so as to form scrolls. In the *Camel* the hind part of the Turbinated bone exhibits a remarkable horizontal, nearly semicircular, convolution, seemingly an extension of the lower plate which rests on the top of the alveolar process in front of the orbit, and compensates for the absence of the cavity in the orbitar part of the lachrymal bone, which exists in the other members of this Order.

The Ploughshare bone (N.) is of considerable length, and curved forwards and downwards; its under edge is very sharp, except the anterior third, which thickens, though still angular, and is generally connected with the nasal crest of the upper jaw-bones alone. In the *Camel*, however, the under edge is straighter, and just behind its junction with the crest before mentioned it has a pair of little thin slits, divided by a middle ridge, in which are received corresponding slender elevations of the palate-bones; the longitudinal groove for the partition cartilage of the nostrils is very wide.

The Lower Jaw (O.) consists of a pair of bones, of which one remarkable character is the length of their branches. The horizontal branch, increasing in depth from before backwards, has its lower edge rounded; the inside of its front extremity is rough for its fibro-cartilaginous connexion with its fellow, and its upper edge outspreading, inclining forwards, thick, and indented with sockets for the incisive teeth, of which the cutting crowns are directed more or less forwards; behind and below the sockets is the large mental hole, from above which the upper edge of the bone continues back, sharp and thin for some length, to the sockets of the molar teeth, which considerably thicken the edge back to the ascending branch, which, compressed from within outwards, and having on its inside the large infra-maxillary hole, terminates above in the thin, slightly curved back coronoid process, which rises above and overhangs the condyle slightly in the *Ox*, but considerably in the *Sheep*. The condyle is broad, widest laterally, its articular surface upwards, and generally slightly concave, to correspond to the glenoid process of the temporal bone. The angle of the jaw-bone is rounded. In the *Camel* the sockets for the incisive teeth are more vertical, and the gap between them and the molar has a socket for the cuspid tooth; the coronoid process is smaller and more upright, and the articular surface of the condyle round; the angle of the bone is more distinct, but high above the base, and not far below the condyle; and the vertical branch is shorter than in the other Ruminant Beasts.



(C.) PREDATORIES.—Two only of the three Families included by Cuvier among his CARNASSIERS can be admitted as belonging to this Order, viz., the Flesh-Eaters and the Insect-Eaters, of which the Heads exhibit remarkable characteristics.

(*) The Flesh-eaters are distinguished by the width and roundness of the Skull above the ears, by its contraction about the middle of the temporal pits, and its re-expansion transversely between the orbits; by the large size of the crests, especially of the parietal portion of the temporal; by the great lateral extension of the glenoid processes rendering their region the widest of the Skull, and by the correspondent extent of the articular sockets for the lower jaw, and their deep concavity narrow from behind forwards, so as to preclude any but a hinge-motion between the bones; by the large vesicular form of the drum cavity; and by the great breadth of the basilar part of the occipital bone.

The Occipital bone (A.) has its basilar process of considerable breadth and nearly square, especially in the *Seals* (Pl. V., fig. 18. A.), in which it is extremely thin, and has a large nearly central aperture filled by membrane; the occipital hole is large, and somewhat diamond-shaped, with the angles before and behind and lateral; the condyles, jutting well backwards, rise a little above the lateral angles, but never to the level of the upper angle, or above, as in Ruminating Beasts. The paramastoid processes do not depend below the condyles: they are compressed from before backwards, and curve backwards and downwards: in the *Cat* (Pl. V., fig. 17.) and *Dog* kind they are of good size, but small in the *Seals*; their front is slightly hollowed to lodge the hind part of the tympanal portions of the temporal bones. The occipital surface varies in height and breadth, and is bounded by the transverse ridge, which is converted into a strong crest of angular shape, and its diverging legs descend into the paramastoid processes, their lower part being more or less perfected by the mastoid pieces of the temporal bones, which participate in forming the back of the Skull. In proportion as the crest is sharp and prominent the occipital surface seems to be sunken, and such it really is in the *Seals*; but in the *Dog* and *Cat* kind it projects in a rounded form between the crest and the occipital hole, indicating the shape and size of the upper vermiform process of the cerebellum. From the upper and fore part of the crest the bone projects its occipital angle, which in the *Dog* kind is very long and wedge-shaped, projects between the hind ends of the parietal bones, and assists in forming their crest; but in the *Cats* and *Seals* is shorter and extended more laterally, so that the parietal bones do not reach back to the crest itself, as in the *Dogs*. The anterior internal surface of the Occipital bone sometimes projects the bony plate or tentorium, which in this Order covers the cerebellum, and supports the back of the cerebrum; it is small in the *Dog*, of considerable size in the *Seals*, but in the *Cats* this bone has nought to do with its formation.

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The Sphenoid (B.) is long and distinct from both occipital and ethmoid bones; it consists of an occipital and ethmoidal, and sometimes of a pair of pterygoid pieces, all separate. The occipital piece, like the basilar process of the occipital bone, is wide; the Turkish saddle and clinoid processes well defined; the spines are wide and overlap the petrous portions of the temporal bones: the temporal plates are tall in the *Dog*, but shorter in the *Seal*, their height being proportionate to that of the temporal bone: they rise upwards, inclining forwards and outwards between the squamous of the temporal and the temporal plate of the frontal bone on each side to the parietal; the outer pterygoid processes in the *Dog* kind are shallow, stretch forward before the body, forming supports for the ethmoidal piece, and are separated in front by a gap from the internal pterygoid pieces or processes, which are deep and long, forming the side part of the plates separating the hind aperture of the nostrils from the orbits; their hook-like processes are little developed. In the *Cat* (fig. 17.) kind there is but one pair of pterygoid processes (B.**), which are not detached, but are very broad and projecting, and curve gently downwards and outwards; their hook processes are long and well defined. In the *Seals* the pterygoid processes are triangular, with their points downwards, and are received entirely within the palate-bones. The ethmoidal piece of the sphenoid is very much smaller in this Order than in the Ruminant; the transverse spines are short, received within, and rest upon the roots of the temporal plates; its front is dug out into the pair of cells of which the sides are bounded by the orbitar plates, the top by the space between the transverse spines and the lower edge of the ethmoidal gap, and the bottom by the rough surface and azygos process for the junction of the ploughshare bone.

The Ethmoid bone (F.) is generally, though not always, larger in proportion to the size of the head than in Ruminant Beasts, and its size is tolerably indicated by the extent of the space between the orbits: thus it is largest in the *Weasel*, *Cat*, and *Dog* kind, small in the *Otters*, but especially small in the *Seals*. The cock's-comb on the sieve-like plate, which is very full of small apertures, is scarcely developed; and a deep cleft above, which nearly divides the bone into two halves, receives the descending nasal processes of the frontal. The convolutions of the bone are much more numerous and complicated than in the former Order, and the cells consequently more numerous. Sometimes, as in the *Dog* kind, the Ethmoid bone does not at all enter into the composition of the Orbit, but in the *Cats* (F. χ.) a very small roundish orbitar plate appears between the orbitar plates of the frontal, lachrymal, and palate bones.

The Frontal bones (E.) are always a pair, the sagittal suture being continued from the junction of the parietal to that of the nose-bones. They vary considerably in extent, are widest, and together render the forehead diamond-shaped, in the *Cats* especially, also in the *Dogs*, *Bears*, and others; but in the *Otters*, and especially in the *Seals*, they are narrow and the forehead of triangular form. This varying width depends on the development of the posterior angular processes (ω.), which never reach the cheek-bones, not even in the *Cats* (fig. 17.), in which they are very long, consequently the orbitar margin is imperfect; but in the *Dogs* they are very short, in the *Otters* still shorter, and in the *Seals* are scarcely discernible; the limit between the tempora. pit behind and the orbit before is also well defined by the length of this process, although, as neither the orbitar plate of the Frontal nor that of the sphenoid is lengthened outwards, the cavities are not in the macerated Skull separated from each other: thus in the *Cats* the distinction between the two is well marked, in the *Dogs* less, and in the *Seals* not distinguishable. The supraciliary ridges or brow margins in the *Cats* are very prominent; and the posterior angular processes standing much outward, direct the plane of the orbits more forward than in others of this Order; whilst on the contrary in the *Otters*, and especially in the *Seals*, the deficiency of the angular process, and the scarcely perceptible projection of the supraciliary ridges beyond the inside of the orbitar plates, throw the plane of the orbits upwards and outwards. The orbitar plates, besides joining the vaults of the orbits, especially in such Beasts as the *Cats*, which have the angular process largely developed, form also their inner wall above the sphenoid, palatine, and lachrymal bones, and enclose between them and the descending nasal spine the corresponding half of the ethmoid bone. The nasal process (τ.) of each bone projects in a pointed form, separated by a gap from the front of the orbitar plate, which receives the upper jawbone, and with its fellow forming an angular gap, in which the hind ends of the nasal bones are received. Both Frontal bones contribute to form the nasal spine, a deep thin process descending from the inner edge of each before and below the cavity of the Skull and the ethmoidal gap. The temporal plates are of large size; they are merely separated from the orbits, each by a slightly rounded edge, which descends from the root of the posterior angular process; but in the *Seals* this is scarcely discernible, and the roughness of the muscular marks alone defines the boundary of the temporal pit from the orbit. From the root of the angular process ascends upwards and backwards a more or less distinctly marked ridge, bounding the temporal pit above, and continued back to the ridge on the parietal, which, with its fellow, forms the more or less lofty parietal crest.

The Parietal bones (C.), though a pair, very commonly at a more or less early period become connected into a single bone, and in either form the sides and vault of the Skull above the temporal and sphenoid bones. The form of each bone is convex oblong, and its greatest dimensions from behind forwards, except in the *Seals*, in which it is from above downwards; in most cases the bone bulges considerably outwards above the ear; hence between them the Skull is usually widest. Generally the bulging is rendered more remarkable by the bone becoming suddenly contracted as if compressed by a cord immediately behind it, and thence splaying upwards and backwards so as either to overlap the horizontal projection of the occipital bone, as in the *Cats*, or by joining with the upraised edge of that bone to assist in forming the occipital crest, as in the *Dogs*. The upper edge of the bone is straight, and rests against its fellow; but the hind upper angle is truncated more or less obliquely, forming a gap between the two bones, in which is received, as in the *Dogs* and *Seals*, the projecting occipital angle of the occipital bone, or, as in the *Cats*, the little triangular bone called by Meckel and Cuvier the Interparietal. The lower edge of the Parietal is scaly, being overlapped by the squamous plate of the temporal bone; it is also arched, and the front lower angle descends between the temporal and frontal bones to join the temporal plate of

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the sphenoid. The temporal ridges, from the angular processes of the frontal bones, generally meet in a point at the junction of the upper front angles of the Parietal bones, and at the union of the upper edges of the latter bones rises up the more or less tall parietal erest ($\phi$.); this deepens as it runs back to the occipital erest, which it sometimes overhangs, and is more developed in the *Hyæna*, but least in the *Weasel* kind. In the *Seals* the temporal ridges diverge backwards rather than converge; therefore, instead of meeting at the front of the sagittal suture, each ridge descends obliquely backwards to the middle of the hind edge of the corresponding Parietal bone; and as in all cases the ridges, either running singly, or when conjoined, forming the Parietal erest, indicate the extent of Skull covered by the temporal muscles, so in the *Seals* a very large triangular surface on the top of the Skull is uncovered by muscle between the diverging ridges. The bony tentorium ($\psi$.), which in the *Cats* is of remarkable extent, projects from the interior of the bones a little in front of the hind edge, from the squamous edge on one side to that of the other, forwards till it laps over the front face of the petrous portions of the temporal bone; in the middle the bony plate is not so far projected, but a square gap is left through which the isthmus of the brain passes. Meckel takes a curious view of this bony tentorium in speaking of his Interparietal bone, the external surface of which, he says, in many, perhaps in all Beasts, diminishing in proportion as the parietal and occipital bones enlarge, and these partly bend over and cover, and partly also diminish its size. On the contrary, it appears on the internal surface of the Skull correspondently largely projecting, and in a higher or lower degree participating in the formation of the tentorium.

The Temporal bones (o.) are remarkably distinguished by the height of their squamous plate, which, besides overlapping the lower edge of the parietal, assist in forming of the walls of the Skull; and upon their elevation depends the depth of that cavity; this is greatest in the *Cats*, of which the squamous plate is tall, and least in the *Otters*, and especially in the *Seals*, in which it is low, and indeed in the latter is so small as to have a close resemblance to the squamous plate in the *Porpesse* kind. The mastoid portion consolidated with the squamous is little developed; it assists the occipital bone in forming the back of the Skull, and the occipital erest is continued upon it to terminate in the indistinct mastoid process which rests on the root of the paramastoid process between it and the bony drum. The glenoid process is one of the most important characters of Predacious Beasts; it projects outwards from the fore and under part of the squamous plate, at right angles with the side of the Skull, and upon its lateral extension principally depends the width of the cheek-arches; on its under surface is the glenoid cavity ($\zeta$.), long from within outwards, narrow from behind forwards, deeply concave in the latter direction, and rendered still deeper on the inside by the lengthening of the hinder lip, and on the outside by that of the front lip, which, in some instances, bend towards each other so as to clip below the condyle of the lower jaw, as in the *Badger*, and prevent its escape from the socket even after all the soft parts are removed. The development of the glenoid process and cavity is greatest in the *Badgers*, *Otters*, *Weasels*, *Bears*, and *Cats*; on the contrary, in the *Dogs*, though the lateral extent is great, yet the cavity is wide and shallow from behind forwards, and the front lip is not specially developed; whilst in the *Seals* the lateral extent is less, but the concavity deeper and both lips more decided. The temporal pulley of triangular shape on the upper surface of the glenoid process corresponds with it in size, and is bounded externally by the root of the zygomatic process ($\nu$.), which springs outwards and forwards to join the corresponding process of the cheek-bone; at first compressed and deep, it tapers as it continues forward, overlapping that process, and in doing so it generally curves slightly upwards, but in the *Weasels* very remarkably, so that when viewed on one side the Cheek-arch forms a vertical as well as a horizontal arch. The hind lip of the glenoid cavity, and a ridge continued from the root of the zygomatic back to that of the mastoid process, are the only indication of a bony external auditory tube, below and between which and the paramastoid process of the occipital bone a large bony vesicle ($^{a}$.) is situated, which descends, in the *Cats*, very considerably below the occipital basilar process, and is very convex from behind forwards, and from within outwards; in the *Dogs* it is flatter; in the *Weasels*, more lengthy; so also in the *Otters*, but still flatter. In the *Seals*, instead of its walls being almost as thin as paper, as they generally are, they are thick, close, and massive, and remarkably recall the shape and appearance of this part in the Cetaceous Order. This vesicle is divided into two parts by a bony partition; the anterior upper one is the drum cavity, with its large external aperture, on which the drum membrane is spread, and the posterior under one answers to a mastoid cell. The well-developed petrous portion of the bone rests upon the top of this cavity and within the squamo-mastoidal portion, but it does not appear externally on the back of the Skull, except in the *Seals*, which is another correspondence with them and the Cetaceans.

The Malar bones (u.) differ from those of Ruminant Beasts by the greater length of the zygomatic process ($\mu$.), which runs beneath the corresponding process of the temporal bone, tapering as it passes back generally to its very root, and taking the corresponding direction; by the shortness of their posterior orbitar process, which not reaching the angular process of the frontal bone, the orbitar margin is deficient behind to a small extent, only in the *Cats* (fig. 17.), in which both these processes are very long; but in the *Weasels*, *Dogs*, *Seals*, and others, where they are scarcely indicated, the hinder third of the orbitar edge is entirely absent. Generally the bone is compressed from within outwards, and can scarcely be described as forming any part of the floor of the orbit; it does so, however, where it curves inwards at the fore and under part in the *Seals*, and especially in the *Cats*, where it rests in a groove on the outer and fore edge of the orbitar plate of the upper jaw-bone. In the *Dogs* it laps against the front of that bone by an indented suture, as in Ruminant Beasts, though not so extensively. The anterior orbitar process runs inwards, forming the very lower orbitar margin, and joins the lachrymal bone.

The Lachrymal bones ($\sigma$.) are of squarish shape, and divided by a vertical ridge into a larger posterior orbitar part, and an anterior narrow but deeper lachrymal part, at the bottom of which is the nasal duct. The bone is entirely within the orbit, between the frontal above, the upper jaw-bone below, and the palatine behind. In the *Seals* there is no trace either of bone or nasal duct.

The Palate-bones (M.) are distinguished from those of

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Ruminant Beasts by the greater length from behind forwards (fig. 17.), and by the diminished height of their orbitar plates, the upper edge of which is connected with nearly the whole lower edge of the orbitar plate of the frontal, whence it inclines downwards and a little outwards, so as to form a partial inner flooring to the orbit, and still more outwards where it joins the orbitar process of the upper jaw-bone. The palate process is very wide, but does not extend to the hind end of the orbitar plate, and therefore, when the bones are in their natural place, the posterior aperture of the nostrils, which is square, is much in front of the junction of the orbitar processes with the pterygoid of the sphenoid.

The most remarkable character of the Upper Jaw-bones (J.) in this Order is the entire absence of any maxillary cell or tubercle, and in its place the expansion of the bone above the sockets of the molar teeth, to form the remainder of the small anterior flooring of the orbit between the palate and cheek bones: this orbitar process is most extensive in the *Cats*, *Weasels*, and *Seals*, in which it juts out more or less beyond the tooth-sockets, and its entire side and front edge grooved to receive the malar bone; in the *Dogs* it scarcely projects outwards, but rises upwards, and therefore, instead of lying on the everted edge, as in the *Cats*, &c., laps against its fore and outer surface; consequently the orbits are smaller, and their plane inclined more outwards than in the *Cats*, &c. The sockets for the teeth are less deep than in the Ruminators, upon which circumstance, together with the absence of maxillary cell, depends the shallowness of the Upper jaw-bone in Carnivorous as compared with that of Ruminating Beasts. The length of the bone in front of its junction with the cheek-bone varies: it is very short in the *Cats* (fig. 17.), *Weasels*, and *Otters*, but lengthy in the *Dogs* and *Coatis*. In the *Cats* and other short-faced Carnivorous Beasts, the nasal process (ξ.) is tall, and both its hinder edge which bounds the inside of the orbit, and its front edge grooved to receive the hind edge of the muzzle-bone, are nearly vertical, so that the process resembles an oblong with its fore and upper angle cut off, upon which the nasal bones rest, whilst the upper edge joins the frontal bone. In the *Dogs* and others of this Order with long faces, the nasal process is of triangular shape; its upper angle truncated to join the frontal; its upper anterior edge very long to join the nasal and muzzle bones, and its front angle truncated to join also with the latter bone. This truncated front end of the bone is always of considerable thickness in consequence of the large socket for the cuspid tooth contained in it. The infra-orbitar canal is short, and opens a little in front of the orbit in the *Dogs* and others with long faces; but in the *Cats*, *Weasels*, and others like them, this canal can scarcely be said to exist, as its length is only the thickness of the orbitar edge, immediately before and below which it opens. The palatine process is short and very wide in the *Cats*, *Weasels*, &c., but in the *Dogs* and *Coatis* it is long and narrow from behind forwards; in all, however, its inner hind angle is truncated, and the angular gap thus formed between the bone and its fellow receives the front of the palate-bones.

The Muzzle-bones (K.) are shorter than in Ruminant Beasts, but higher and sometimes wider, and their lower margin is considerably more bulky in consequence of its furnishing sockets for the teeth with which Predacious Beasts are provided, but which among the Ruminators are found only in the Camel Family. These sockets are either entirely confined to the front edge of the palate-plate, as in the *Cats* (fig. 17.), *Weasels*, *Seals*, &c., or are continued along the under edge of the nasal plate, as in *Dogs*, and then the socket for the large cuspid tooth is formed partially by this bone, and in part by the upper jaw-bone. The front edge of the nasal plate generally rises almost vertically to the palate; consequently the plane of the nasal aperture, which it bounds, is the same; if the face be short, this plate is short from behind forwards, but tall and pointed, with its tip just overlapped by the nasal bone, as in the *Cats*; but if the face be long, the plate is longer though less tall, and from its upper and back part a long pointed process runs between the nasal plate of the upper jaw and the nose-bone, as in the *Dogs*. The nasal plate in the *Seals* differs in being almost concealed within the nasal plate of the upper jaw-bone, so that its edge only is apparent, and very oblique in correspondence with that of the jaw-bone.

The Nose-bones (L.) together form by their upper surface a long triangle, of which the apex is received between the nasal processes of the frontal bones, the base between and its angles slightly overhanging the muzzle-bones, and the edges resting on the upper nasal edges of the upper jaw-bones. The inner edges of the two bones descend considerably, and their junction perfects the keel partially formed by the frontal bones, which descends to the partition-plate of the ethmoid bone.

The Turbinated bones (P.) in this Order are generally largely developed, the convolutions being so numerous that the interspaces often resemble the transverse section of the vessels in a piece of cane, or like the cancellated structure in the interior of a cylindrical or irregular bone. In the *Weasel* kind the convolutions are so numerous that they all but fill up the cavities of the nostrils; and in the *Otters* and *Seals* (fig. 18. P.) they are still more developed, and entirely fill them. In the latter animals the free front ends of the convolutions thicken and are rounded, assuming the appearance of the branchings of a shrub, and becoming more and more delicate as they approach the bony partition of the Nostrils. In the *Cat* kind (fig. 17.), as observed by Rapp, the organ of scent seems to be weakest among Predacious Beasts; and in them alone is the dichotomous arrangement of the convolutions almost entirely deficient, the Turbinated bone sending inwards only a single plate, which descends and is twisted from within outwards upon itself.

The Ploughshare bone (N.) is generally not of large size, and connected only with the nasal ridge formed by the junction of the palatine processes of the upper jaw-bones; in the *Seals*, however, it is connected also with the same processes of the palate-bones, and reaches back quite to the lower edge of the hind opening of the nostrils.

The Lower Jaw (O.) has the junction of its horizontal branches more extensive in this than in the Ruminant Order, and the angle which they form is more open in consequence of the wider outspreading of their hinder extremities, dependent on the greater distance apart of the glenoid cavities. The front end of each branch splays a little outwards, and has a squarish form owing to the size of the sockets which contain the large cuspid teeth; between these, on the front of the conjoined branches, are one or two rows of sockets for the incisive

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Zoology. teeth, and behind them, extending back to the roots of the coronoid processes, are the sockets for the remaining teeth; sometimes immediately behind the cuspid is a gap into which passes the cuspid of the upper jaw. The ascending branch is much shorter than in Ruminant Beasts, and is remarkable for the great development of the coronoid process (a.), which rises vertically to the upper margin of the horizontal branch; its size indicates that of the temporal muscle, and consequently the prehensile power which the jaws are capable of exerting. The condyle (b.), placed on the back of the ascending branch, is transverse and lengthy, and in shape resembles the vertical section of a cylinder placed horizontally, with its convexity backwards, and corresponding in shape and extent to the glenoid cavity in the temporal bone. In proportion to the height at which the condyle is placed on the back of the ascending branch, is the length of the coronoid process, which is the lever employed in the motion of the jaw, the condyle itself being the fulcrum on which it moves. The movement performed by the Jaw is simply vertical, like a pair of shears, of which the upper fixed blade is represented by the Upper, and the lower movable one by the Lower Jaw. All other motion save this is entirely precluded by the transverse extent of the condyle, and by the embracement it receives from the overhanging lips of the correspondingly transverse and deep glenoid cavity; the food can therefore only be cut, but not ground, as it is by the horizontal motion of the jaw in Ruminant Beasts.

(**) The Insect-Eaters are principally characterized by the wedge-shape of their Head, suited to their burrowing habits, and by the extent and flatness of the articular surfaces for the lower jaw. In some the zygomatic arch is entirely deficient.

The basilar process of the Occipital bone (A.) is usually wide; its great hole of good size; its condyles not very strongly developed. The occipital surface is vertical and flat in the *Shrews*, *Sorex* (fig. 23.), *Hedgehog*, *Erinaceus*, and *Tenrec*, *Centetes*, and in the latter very tall; but in the *Mole*, *Talpa*, and the *Golden Mole*, *Chrysochloris Capensis*, the hind head is rounded and bulges very considerably back behind the ears, especially in the latter, where it forms a lower and two upper long convexities. In the *Mole* there is not any crest, but in all the rest there are both occipital and temporal crests: these are sufficiently well marked in the *Hedgehog*, but in the *Tenrec* the occipital crest is of great height; in the *Musky Shrew* also very decided, but divided into two by a middle cleft, and both portions much overhanging the back of the Skull. If the hind bulging in the Skull of the *Golden Mole* (Pl. V., fig. 22.) be, as seems to be the case, although very difficult to determine on account of the early confluence of the Head-bones, dependant on the large size of the Occipital bone, it strongly recalls the large Occipital bone of the Porpesse Tribe; and this similarity is rendered still more close by the peculiar form of the occipital ridge, which forms a thin edge overhanging forwards, and terminating below on either side in the elevated part of the zygomatic process of the temporal bones.

The Sphenoid bone is generally of considerable length; but its body being narrow, and the roots of the deep pterygoid processes very close, the hind aperture of the nostrils is comparatively tall and narrow. In the *Hedgehog* (Pl. V., fig. 19.) the inner pterygoid plates, with well-marked hook processes, are separated by deep and wide pits from the external plates, which jut out almost horizontally; from the hind end of the root of each inner pterygoid plate a large concave plate (ρ.) stretches backwards beyond the posterior surface of the body of the bone, forming internally a mortise, which receives the basilar process of the occipital, and, externally, the inner part of the imperfectly bony drum cavity. The root of the outer pterygoid also sends outwards a shallower concave plate (σ.), which runs to the glenoid surface and forms the front of the drum cavity. In the *Tenrec* (fig. 20.) the pterygoid processes each consist of but a single plate (π.), very stout and of great length; its hinder end continued along the side of the basilar process of the occipital bone forms the inner wall of the drum cavity, and a smaller shallower one stretching outwards juts against the glenoid surface and forms its front. In the *Hedgehog* the temporal plates are very large; posteriorly, where much underlapped by the squamous parts of the temporal bones, they are more outspread than in front, where they are more upright, underlap and completely include the Ethmoido-sphenoid bone, which is intimately connected by the front of its transverse spinous processes with the large Ethmoid bone.

The Temporal bone in the *Hedgehog* is divided into the squamous and mastoido-petrosal portions. The vertical part of the squamous plate is long but not high, and its horizontal part, rather large and square, assists the glenoid process in forming the large and flat articular surface for the lower jaw; the zygomatic process, neither deep nor thick, stretches outwards and forwards to the cheek, which, overlapping, it joins, and the latter is continued forwards to the large malar process of the upper jaw-bone, the three bones together forming a very wide temporal pit. The back of the mastoid process helps to form the back of the Skull; its side is large and its base hollowed to assist in forming the drum cavity, in which also the under surface of the petrous piece participates as well as the hind end of the sphenoid bone already mentioned. Whether there be any special bony drum or external auditory passage is doubtful. It is difficult to determine whether in the *Common Mole* the Temporal bone consists of one or several pieces; it is, however, low, and of considerable length, which depends on the large development of the part corresponding with the mastoid process into a broad surface convex externally, and forming the hinder rounded corner of the Skull between and below the parietal and occipital bones. The scaly part inclines much inwards and forwards, has a small glenoid process and articular surface, and sends forwards and a little outwards the zygomatic process (fig. 21. ν.) to the slender Cheek-bone, the front of which rests on the malar process of the upper jaw-bone; the zygomatic arch formed by these bones being nearly straight and the temporal pit narrow, does not spread out beyond a line from the mastoid process to the muzzle. In the *Golden Mole* (fig. 22.), the upper hind edge of the zygomatic process (ν.) rises high upon the front of the occipital crest, and with it overlapping the side of the parietal bone, or perhaps the squamous plate of the temporal itself forms between them a deep thin cleft on the side of the head. The front extremity runs forwards and inwards, joins the Cheek-bone, which continues in the same direction to the upper jaw-bone, rendering the zygomatic arch completely straight. The

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articular surface is not large. The ear-drum is large and vesicular, and seems to belong specially to this bone. In the *Tenrec* (fig. 20.) the Temporal bone is very long; its large mastoid process is flattened vertically: the articular surface (s.) for the jaw is of enormous size, concave downwards, and stretching obliquely from within outwards and backwards. The only indication of zygomatic process is a simple stud (b.), and the Cheek-bone is either really wanting or generally lost, so that the zygomatic arch is considered to be deficient. In the *Indian Shrew* (fig. 21.) the mastoid process is largely expanded laterally and forward. The jaw-socket has its hind lip (a.) of great depth, and, curving forwards, it underlaps the inner end of the condyle of the lower jaw, which is convex downwards and backwards. In this animal also there is but a zygomatic stud, and no cheek-arch.

The Parietal bones in the *Hedgehog* are oblong square, arched laterally, and their junction forming a low crest, which bifurcates behind where the angle of the occipital bone is thrust in between them. In the *Tenrec* their ridge is high and sharp; the bones themselves descend aslant to the temporal bones, and their hind edge is oblique, being trenched on by the occipital bone and by the large mastoid process. The *Indian Shrew* (fig. 21.) has also this roof-like form of the parietal bones, but they are flatter. In the *Common Mole* these bones, are very large, and considerably wider behind than in front, but they have not any crest. It is almost impossible to define in the *Golden Mole* (fig. 22.) how much of the Skull in front of the occipital crest is formed by the Parietal, and how much by the frontal bone. The irregular diamond-shaped space (b.) on the top of the Skull, and in front of the occipital crest is probably formed by the occipital and parietal bones, and from its front angle a flat space continues forwards, widening more and more as it runs upon the face. On each side of the diamond space a remarkable rounded angle (c. e.) projects nearly as far out as the elevated root of the zygomatic process; and these are considered by Pander and D'Alton as belonging to the Parietal bones. From their inner and fore part projects forwards on either side a nearly straight edge, which terminates at the lachrymal or at the upper jaw bone.

The Frontal bones are a pair: in the *Hedgehog* their hinder edge is considerably overlapped by the parietal bones, so as materially to diminish their apparent size: the flat triangular frontal surface is bounded by the divergence of the parietal crest into a pair of slightly elevated lines, each of which terminates in a little anterior angular process, in the formation of which the top of the lachrymal bone and the nasal process of the upper jaw-bone participate. Behind this process the bone is contracted as it descends to form part of the temporal pit; but no posterior angular process exists. The nasal process stretches forward, and entirely separates the nose-bone from the upper jaw-bone, but receives the former bones in the narrow gap between itself and its fellow. In the *Tenrec* the parietal crest is continued onwards at the junction of the Frontal bones to the divergence of their nasal processes; the frontal surface of each bone inclines outwards and downwards, so that the Skull from the root of the nose back to the occipital crest resembles a trigonal prism. In the *Golden Mole* the frontal surface of the bone is narrow, but its orbitar parts large and rounded from above downwards and outwards. So also is the Common Mole, but in neither is there any angular process. The Cheek-bones, and consequently the zygomatic arches, exist in some, but are deficient in other members of this Family. They are present in the *Hedgehog*, and arched considerably outwards and lengthy: the *Mole* also has them (fig. 23. H.) curved, but shorter and more slender: in the *Desman, Mygale Pyrenaica*, they are shorter, straighter, and deeper; and in the *Golden Mole* (fig. 22. H.), they are still shorter and deeper, run forwards and inwards, forming the sides of a triangle of which the hind head is the base. In the *Tenrecs* (fig. 20.) and the *Shrews* (fig. 21.) the Cheek-bones are wanting. In the former animal the malar processes of the Upper Jaw-bones are deep, stretch outwards and backwards, form the fronts of the orbits, and terminate each in a slightly elevated process analogous to the posterior orbitar process of the cheek-bone. In the latter animal the only indication of malar process is the remarkably flat outstanding angular process (J.) which lodges the hinder grinding teeth. The Upper Jaw-bone is not, in this Family, generally very long, but it is so in the *Tenrec*, and its front end is very full to form the socket for the large cuspid tooth. The side of the Muzzle-bone is also deeply grooved to receive the tall point of lower cuspid. In the other individuals of this Family the upper cuspid teeth, as well as the incisive, are supported by the Muzzle-bones, which in the *Golden Mole* (fig. 22. K.) are of remarkable shape, their front extremities first diverging and afterwards curving inwards towards each other. The Lachrymal bones, though not always separable, are distinguishable, and assist to form the front edge of the orbit, even in the *Hedgehog*, in which Pander and D'Alton say it is difficult to determine whether it exists.

The Lower Jaw, consisting of two pieces, corresponds as usual in length with that of the temporal pits: thus in the *Tenrec*, in which both are very long, and the glenoid cavities close to the back of the Skull, the Lower Jaw is very long, nearly equalling the whole length of the Head, and, like its other bones, very massive. But on the contrary, in the *Common Mole*, which has the glenoid cavities far forwards and the temporal pits short, the slender Lower Jaw is short also; and in the *Golden Mole* still shorter, not reaching the tip of the Muzzle. In the *Indian Shrew* the condyle has corresponding shape with the peculiar shaped articular surface on which it moves.

(D.) Bats.—This group of animals is by most zoologists, excepting Illiger, placed among the Predatories; a disposition certainly improper, at least as regards one Family which feed on fruit. And although the insect food of the other Family and their masticating organs bring them into near approximation to the Insect-eating Predatories, yet other parts of their organization are so decidedly peculiar as to justify their formation into a distinct order, as proposed by Illiger, who named it *Volitantia*.

The Roussettes (Pl. V., fig. 24.) are principally distinguished by the form of the Head; by the pyriform shape of the skull, widest in front and above the ears, and narrowest behind the orbits; by the large curve backwards and forwards of the parietal bones to their junction with the occipital crest, of which the highest point is not far above the occipital hole; by the lofty upward curving of the zygomatic processes of the temporal bones, and the great capacity of the temporal pits; by the large development of the posterior angular processes



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of the frontal bone; by the great length of the jaws depending upon the distant location of the teeth from each other; and by the square projection of the muzzle before the upper jaw-bones.

The Occipital bone (A.) has its great hole very large and angular above; its condyles large; its basilar process, with a slight longitudinal keel on its under surface, is very wide, thin, and rising obliquely upwards to its junction with the sphenoid bone: the occipital part is very low, and nearly vertical up to the semicircular or angular crest; and above this a triangular piece separates the inner hind edges of the parietal bones, and has on it the continuation of the parietal crest: the petramastoid process is distinct but not large.

The Sphenoid bone (B.) consists of an occipital and ethmoidal piece. The body of the occipital piece, at first wide, narrows in front as it joins the still narrower ethmoidal piece, and along the under surface of both runs a shallow keel to the ethmoid bone: the temporal plates separate the temporal from the frontal bones, and the spinous processes are continued back between the former and the occipital bone: the external pterygoid plates (B.*), of a triangular form, stretch out almost horizontally; but the internal plates (B.**), which Pander and D'Alton describe as distinct bones, similar to those of the Horse, descend vertically, and curve slightly inwards; a shallow pterygoid pit exists between the processes on each side behind, and as they approach in front they enclose the pterygoid processes of the palate-bones.

The Parietal bones (C.) are large and long, nearly as much curved from before backwards as laterally; their inner hind ends are separated angularly by the occipital bone, and their front ends by the lengthening of their temporal surfaces, nearly to the orbitar processes of the frontal bone, form a square gap in which the hinder end of that bone is received.

The squamous plate (a.) of each Temporal bone (D.) is of good size; the glenoid process stands far out, and the zygomatic process ($\pi$.) curves from it at first a little outwards and then forwards and slightly inwards, deep and compressed, and at the same time rising considerably upwards renders the middle of the zygomatic arch much higher than the articular surface for the lower jaw, which is wide, shallow, and guarded with a hind lip only. The mastoid portion and its process (b.) are not large, and form one with the squamous portion, and assists in perfecting the lower part of the occipital crest. The ridge from the root of the glenoid to that of the mastoid process, running above the external auditory hole, is not very prominent; nor is there any external bony auditory tube. The petrous portion (c.) is distinct, and the bony drum cavity not large.

The Frontal bone (E.) seems to be single; its frontal part lengthens backwards in a square shape between the parietal bones, and stretches forwards between the orbits, nearly of equal width throughout, to its junction with the nose-bones, between the ends of which it in some instances projects a little point, but in others forms a little gap for their reception. The parietal crest continues on the frontal surface nearly to the orbits, where it bifurcates and runs into the curving and descending well developed posterior angular processes (e.), which taper to a point as they form the hind boundary of the orbits, but never descend to the cheek-bones. The brow-ridges (f.) are well marked, and their front ends are separated by the lachrymal from the upper jaw-bones. Their orbitar plates descend deeply in the orbits, perhaps to the palate-bones, but are not separated from the temporal plates, which are very small.

The Palate-bones (M.) are very long, extending through the middle third of the whole length of the head, from the occipital hole to the muzzle; their palate-plates, forming an oblong square, are continued between the tooth-sockets of the upper jaw-bones, as far forwards as the second pair of molar teeth; their nasal plates, lengthy, but not very tall, perhaps reach the orbitar plates of the frontal, and behind are continued as pterygoid processes beyond the posterior opening of the nostrils, between the pterygoid processes of the sphenoid bone.

The Cheek-bones (H.) are compressed, have a wavy form as they stretch forwards and a little inwards to be received into the malar processes of the upper jaw-bone; their front half is deepest, forms the hinder half of the lower edge of the orbit, and is rendered concave by the elevation of the short and pointed posterior orbitar process (g.), the large gap between which and the posterior angular process of the frontal is filled by ligament; the hind half of the bone curves a little upwards, and underlapping the zygomatic process of the temporal bone with it, perfects the zygomatic arch.

The Upper Jaw-bones (I.) are long and deep, and their nasal processes inclining inwards as they ascend to join by their upper edges with the nose-bones, give the face the form of a triangular prism, of greater width behind than in front, and with its upper edge truncated: the palate-plates, slightly arched laterally, and wider behind than in front, where their straight transverse edge forms the posterior edge of the incisive hole, are lengthened considerably at their back and outer edges by the sockets which support the two hindmost pair of molar teeth, and form the sides of the gap in which the palate-bones are received: the malar process ($\rho$.) of each bone, large and trigonal, juts above these sockets from the back and outer part of the bone, and forms the lower margin and small bony floor of the orbit, its extremity also being indented for the reception of the front end of the cheek-bone, and its root perforated by the small infra-orbitar hole; the front molar sockets are separated by gaps from the large socket which in each bone at its extreme fore and outer part lodges the cuspid teeth.

The Lachrymal bones (B.) are distinct, and the orifice of each nasal duct external to the orbit.

The Muzzle-bones (K.) each consist of a nasal plate, which curves outwards and upwards on the front edge of the nasal plate of the upper jaw-bone; and the lower end of each plate curves forwards and inwards to its fellow, forming sockets for the incisive teeth: this transverse process is less wide than the front of the jaw-bones, and thus forms a projecting narrow special muzzle before them; palate-plates do not exist, and consequently a large and nearly square incisive hole (h.) is formed.

The Nose-bones (L.) are longer than the upper jaw-bones, widen as they extend forwards, are arched laterally as they pass between and above the nasal plates of the muzzle-bones, which they project beyond as they overhang the nearly vertical triangular aperture of the nostrils and form its base.

The Lower Jaw-bone consists either of a single piece, or its two halves are very early consolidated; its horizontal branches, inclined outwards, are of equal depth, or nearly so, throughout, except from the roots of the



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Zoology. first pair of molar teeth, whence they wind obliquely upwards to the front of the bone; the base of these branches is generally straight, but sometimes concave from behind forwards. The ascending branches occupy about one-third of the whole length of the bone: the coronoid processes very spacious; the condyles not very projecting, with their articular surfaces largest transversely and nearly flat, are near the angular processes, which project in a rounded form behind them, and are broad from without inwards.

(**.) The Leaf-nosed Bats (Pl. V., figs. 25. 26. 27. 28.) have the skull less narrowed behind the orbits, of which the posterior angular processes are little or not at all developed; the longitudinal parietal curve is shorter; the mastoid processes are very large and thin, throwing the auditory holes and glenoid processes much forward, and rendering the zygomatic arches shorter and less convex above; the face much shorter and broader. In this Family are included the *Vampire Bats*, *Phyllostoma* (fig. 25.): one species, *P. Spectrum*, is as celebrated for the evil though unfounded report of their blood-sucking propensity as it is remarkable for the enormous length of the Head, which is at least half as long as the body.*

The Occipital bone (A.) has its great hole very large, and widest transversely; and the broadest part of the condyles is at its greatest width, whence they narrow as they approach each other below: the under surface of the wide basilar process has a pair of well-marked broad shallow pits (a. a.) separated by a middle keel. The occipital part rises upwards and backwards, and is overhung by the strongly developed crest, below each lower end of which is a lengthy cleft (b. b.); but these are not always present.

The Sphenoid bone (B.) is shorter than in the *Roussettes*, but very wide; its temporal and orbitar plates small; and its pterygoid processes (c.) seem to consist each of a single plate.

The Parietal bones are short, but broad; their hind under ends separated by the projection between them of the occipital bone, on which is the beginning of the parietal crest well developed and perfected by the junction of the parietal bones.

The Temporal bones have their mastoid processes (d.), especially in *P. Hastatum*, largely expanded outwards and downwards, forming a pair of somewhat square projections, convex above and concave beneath behind the external auditory opening and the bony drum cavity, which is vesicular, and has a little projecting point, from its fore and inner part, like that of the *Cat* and some other Beasts. The glenoid processes stand out at right angles with the sides of the Head, and their articular surfaces (ζ.) are deeper, with the hind lip more developed; the zygomatic processes stretch directly forwards from them, and scarcely rise above the horizontal plane of the Skull. The petrous portion (f.) is a distinct bone; it does not appear on the back part of the Skull, and both it and the drum are separated by a cleft from the occipital and sphenoid bones.

The Frontal bone (E.) is widest in the *Nycteris* kind (fig. 26.), which has the frontal surface (a.) very concave, and the posterior angular processes (e.) distinct, though much shorter than in the preceding Family, and the upper edge of the orbits well defined. But generally, as in the *Vampires*, the frontal surface is flat or convex; the posterior angular processes scarcely distinguishable; and in some, as the *Glossophagæ* (fig. 27.) and the *Desmodi*, not existing, so that the temporal and orbitar cavities are confluent. Zoology.

The Palate-bones (M.) have the outer part of their palate-plates much lengthened, so that an angular cleft is formed between them.

The Upper Jaw-bones (J.), generally short in front of the orbits, are shortest in the *Desmodi* and *Nycterides*, but in the *Glossophagæ* (fig. 27.) are very long, resembling in some degree those of the *Mole*; the hinder molar teeth-sockets are continued backwards, forming the floor of the orbits, of which the lower margins are the upper edge of the short out-jutting malar processes.

The Muzzle-bones (K.) scarcely project beyond the sockets of the euspid teeth in the *Vampires*, but their front is wide, and they support many incisive teeth; the incisive holes are very small. In the *Rhinolophi* (fig. 28.) and *Nycterides* Cuvier describes them as forming "two little oblong plates, notched behind for the incisive holes, and suspended by their posterior inner branch to the maxillary bones towards the palate." De Blainville says they are always deficient in the *Rhinolophi*, and imperfect in *Rhinopoma* and *Taphozous*.

The Cheek-bones are long and narrow; sometimes they indicate a small posterior orbitar process.

The Nose-bones are short and not reaching the extremity of the muzzle; the aperture of the nostrils is oblique.

The Lower Jaw-bone consists of two pieces, which unite by finely toothed surfaces in front, which is wide: the horizontal branches incline outwards, and the ascending branches are spacious; the angular processes are square, and project backwards; the condyles are at right angles with them, transverse and convex from behind forwards; and the coronoid processes, far in front, and separated from them by shallow concavities, are not tall, but angular.

(***.) Among the Leafless-nosed Bats are the restricted Linnæan *Vespertiliones* (fig. 29.), of which alone are our English Bats, the *Noctiliones* of Linnæus, and the *Cephalotes*, *Molossi*, and *Taphozous* of Geoffroy, all of which have their muzzle unfurnished with the membranous expansion which characterizes the preceding Family.

The most remarkable character of the Heads of this group seems to be the height of the occipital bone to the top of its crest, from whence the parietal crest is at once continued forwards on nearly the same horizontal plane with the nose-bones, as in our *Noctule Bat* and in many of the *Molossi*, so that one continuous and nearly level line runs from the tip of the occipital crest to the extremity of the nose-bones. Or the parietal crest continuing straight, or nearly so, to its junction with the frontal bone, the frontal surface of that bone curves downwards less or more suddenly, as in *Taphozous* and *Noctilio*, so that it forms an elevated globular forehead high above the plane of the face, which, in two species of *Vespertilio*, engraved in De Blainville's *Osteographie*, is on the same level as the top of the great occipital hole. The skull is widest above the mastoid processes, or above the auditory holes in the large tympanal vesicles, which are so far back as almost to intrude on the occipital surface. The zygomatic arches are short and squarish, sometimes slightly convex above, sometimes straight, or even slightly convex below. The lower margin of the orbits is so little

* This family is principally described from *Phyllostoma hastatum*.



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distinct, that in *Molossus Cestoni* its floor seems confluent with the side of the face. The upper jaw is generally short, and owes part of its length to the muzzle-bones, which Cuvier describes as "forming on each side an appendage of the maxillary bone, and not joining its fellow in the mesial line, so that the muzzle is cleft by the front of the palate, as at the nasal aperture, or that the nostrils and incisive hole form one and the same opening in the skeleton." This may be seen in the *Noctule Bat* (fig. 29. a.). He also adds, "The *Megaderms*" (which, however, are Leaf-nosed Bats), "having no incisive teeth, have nothing ossified, and the whole inter-maxillary region is cartilaginous." The lower jaw has its base deeper on the front than at the sides, and the ascending plate nearly square, with its upper front angle, or coronoid process, slightly higher than the condyle, and the lengthy angular process stretching back from the lower hind angle, in the *Bats*, *Vespertilio*; but in the *Molossi* the ascending branch is oblong, the coronoid process much further distant from the condyle on the same level with and sometimes even below it, as in *M. Mops*.

(E.) Edentates.—In the attachment by Cuvier of this designation to a very remarkable group of Beasts, it must be borne in mind that he employs it only with reference to the absence of the front or incisive teeth, as some kinds have both cuspid and molar or grinding, some have molar teeth alone, and but four kinds of the whole Order are entirely toothless. His division into the two families, Tardigrade and Monotrematous, is well borne out as well by their habits as by their anatomical characters; but his third family, the Common Toothless, is misnamed, at least so far as regards the *Armadillos*, although it fully designates the *Ant-eaters* and *Pangolins*, to which it were better restricted; whilst Illiger's family name, Banded, more correctly indicates the bony bands which, like jointed armour, envelope the trunk, as do similar plates the head of the *Armadillos* and *Pichiagos*.

(*.) The Tardigrade or Slow-moving Family, which includes the *Sloths*, *Bradypus* (Pl. IV., fig. 5. & 5.*), is characterized by the descending process from the lower edge of the cheek-bone, and the lengthening upwards and backwards of the hind angle of the posterior orbitar process, and the entire separation of this bone from the zygomatic process of the temporal; the great length of the temporal pits, at least two-thirds of the total length of the head; the extreme shortness of the muzzle, and the little developed muzzle-bones.

The Occipital bone has its basilar process thin, wide, and flat; its large hole is oval, with its greatest diameter vertical; the condyles are long, vertically convex from side to side and from above downwards, and face almost outwards; before the transverse Occipital crest, a triangular piece projecting horizontally is inserted in the gap at the hind edge of the parietal, but below it the whole occipital part of the bone with the condyles stretch backward like a wide low cone; the paramastoid processes are distinct, though small; and the outer edges of the occipital part being deficient, the mastoid portion of the temporal assists in perfecting the hind head.

The Sphenoid bone has its body wide, and its spinous processes little developed, but its temporal plates moderately large; its pterygoid processes have each but a single plate of considerable depth, and stretching back to the ear-drums of the temporal bones. In the *Collared Sloth*, *Bradypus torquatus*, and also in the *Unau*, or *Two-toed Sloth*, *B. didactylus*, according to Cuvier, these processes contain cells which communicate with the cell in the body of the bone; none such, however, are found in those of the *Aï*, or *Three-toed* species, *B. tridactylus*.



The Parietal seems to be a single bone, with a broad smooth middle space slightly arched forwards, forming the crown, and bounded on either side by the long slightly developed temporal crests, below which the bone bulges outwards specially above the ears, and arches downwards to its junction with the long straight-edged low squamous plate of the temporal bone on each side, which reaches the frontal in front, thereby separating the parietal from the sphenoid bone; the under part of the squamous part runs inwards to the very root of the pterygoid process of the sphenoid. The mastoid processes, as already mentioned, perfect the back of the Skull, and from the front of each projects the deep compressed zygomatic process (fig. 5*. ζ.), which terminates rather before the middle of the temporal pit in a blunt point, without reaching the cheek-bone. The front of the process has a shallow groove above for the temporal muscle, and another at its root beneath, less lengthy, more shallow, and concave transversely for the condyle of the lower jaw, behind which is the aperture of the drum, and below it the drum itself, not very prominent, but with a sharp keel depending from its inner edge.

The Frontal is either a single bone, or the two are early united; its frontal surface is arched forwards, and also laterally; the middle of each side is lengthened by the projection outwards of the posterior angular process, into which from behind is continued the curved termination of the temporal crest, and in front the curved rounded upper edge of the orbit runs onwards to the anterior angular process, which with its fellow projects beyond the front edge of the bone with a wide square gap between them for the reception of the nose-bones. The temporal plate descends to the temporal plate of the sphenoid, and its hind edge joins the parietal bone and the squamous plate of the temporal; the lower edge of the orbitar plate, which is very deep, rests on the palatine, upper jaw, and lachrymal bones.

The principal part of the Palate-bones is their pterygoid process, which is square, of considerable size, and interposed between the pterygoid of the sphenoid and the back of the upper jaw-bone; its upper edge joins the lower margin of the temporal plate of the sphenoid, but does not enter into the orbit; the palatine process is a mere narrow slip of bone passing behind the tuberosity of the upper jaw-bone inwards and forwards to meet its fellow at an angle, but even after their junction the palate is exceedingly narrow.

The Upper Jaw-bones have more than half their length assisting to form the inner under surface of each orbit; the nasal plates are therefore very short, and consequently the muzzle as little projecting as in the *Cats*; the orbitar plate is low, and indeed really formed by the outer plate of the teeth-sockets: but the nasal plate is deep and nearly square; the malar process juts out between the two plates, and above its root is a little gap for the lodgment of the Lachrymal bone between it and the frontal. The palate-plates are narrow, but rather widen in front, so that the palate itself is broader before than behind; the sockets for all the teeth except the front pair are large, but these are small.

The Nose-bones are very wide, and give to the Face

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before the Orbits a square shape; they are longer proportionally in the *Unau* than in the *Aï*; the aperture of the nostrils is square and vertical.

The Cheek-bones (fig. 5. *n*.) are the most remarkable throughout the whole Class of Beasts; the concave portion stretching outwards and backwards forms the lower part of the orbit, is deep, compressed, and bounded by the posterior orbitar process ($\pi$.), well marked in the *Unau*, but less distinct, though sufficiently apparent in the *Aï*; in neither, however, does it rise up to the posterior angular process of the frontal; the orbitar margin consequently remains deficient. From its hind edge a flat process ($\rho$.) stretches backwards and upwards, which might be considered the zygomatic; it does not, however, join that process of the temporal bone, but is continued up into the temporal pit midway between it and the angular process of the frontal bone. The most remarkable part of the Cheek-bone is the flat process ($\sigma$.), which from the middle of the under part of the orbitar portion proceeds downwards and backwards to the outside of the ascending plate of the lower jaw, which is thus enclosed between these processes of the Cheek-bones nearly in the same way as the lower jaw of the Acanthopterygious Fishes is enclosed by the descending branches of their upper jaw-bones.

The Muzzle-bones, according to Cuvier, in the *Unau* are small, toothless, have only the two horizontal (palatine) branches, and do not rise on the sides of the nostrils; but they unite early with the palate-bones, and the incisive holes are small and round. On the contrary, in the *Aï* they do not unite by bone with the palate, but commonly drop out and are lost; their front branch is very small.

The Lower Jaw is very large, and that portion of it supporting teeth very stout, and occupying rather less than the anterior half of the bone; the front of the jaw has no teeth, is wide, and nearly square, the upper edge sharp and projecting; a small angular point stretches far before the rounded base, so that the inferior opening of the horizontal branches only reaches so far as the root of the second tooth. The hinder half of the Jaw is largely developed and very thin; the coronoid, condyloid, and angular processes of each branch are placed obliquely below each other from before backwards. The coronoid process, flat and tallest, is separated by a deep semilunar notch, from the condyle of which the neck inclines backwards, and its articular surface, lengthened in the same direction, is convex laterally; a long but shallower notch from its root terminates below in the long and slightly incurved angular process.

(**.) The Banded Family, including the *Armadillos*, *Dasypus* (Plate IV., figs. 14.* 20.), and the *Pichiagos*, *Chlamyphorus*, have the head very flat, and of a wedge-like or triangular shape, principally depending on the narrowing of the face towards the muzzle.

The Occipital bone has its basilar process thin and wide in the *Nine-banded Armadillo*, *D. Novemcinctus*, but in the *Weasel-headed* species, *D. Sexcinctus*, is still wider; the condyles in the former species are wide laterally and extend to the extreme outer edge of the bone, but as regards the basilar process are directed more downwards than backwards, and are more lengthy than in the latter, but they do not extend so far outwards; but in neither is there any paramastoid process. The occipital piece in the *Nine-banded Armadillo* is nearly square and vertical as high as the occipital crest, which is straight and perfected by the union of the occipital with the parietal bones; its edge is perfect, with two remarkable stumpy processes behind the occipital crest, which is not very decided. In the *Weasel-headed* species the occipital piece is irregularly triangular, and the crest bends backwards, forming a projecting lip; the sides of this piece are deeply incut, to receive the back of the mastoid process of the temporal bone.



The Sphenoid bone in the *Nine-banded* species is a distinct single bone; its body is very wide, and the Turkish saddle well marked; the spinous processes are little developed, but the temporal plates are largely extended forwards; the pterygoid processes consist each of but a single plate, which, instead of being flattened laterally, as usual, are flattened from behind forwards, curve in that direction, gradually thin towards their tips, and are interposed between the ethmoid bone in front and the up-turned palate-bones behind. In the *Weasel-headed Armadillo* the Sphenoid is divided into an occipital and an ethmoidal piece, each consolidated with the neighbouring bone; the body of the Occipito-sphenoid is very wide, and its upper surface slightly convex, instead of hollowed, for the Turkish saddle; the pterygoid processes are flattened laterally, and their lower convex edge rests upon the lengthened palate-bones; the Ethmoido-sphenoid has its transverse spinous processes well developed and received within the edges of the ethmoidal gap in the frontal bones.

The Ethmoid is of very considerable size, forming the whole front of the cavity of the Skull, and on the sides, in the *Nine-banded Armadillo*, materially assisting in the formation of the temporal pits by a pair of broad thin surfaces, which occupy the whole space between the sphenoid behind, lachrymal and upper jaw-bone before, frontal above, and palatine below. In the *Weasel-headed* species a very small flat plate appears in the temporal pit, between the ethmoido-sphenoid behind and the upper jaw-bone before, the frontal above, and the palate-bone below. The sieve-plate in the former species is oval, deeply hollowed, with a middle crest overhanging on either side, and from which stretch out radiating lines of minute apertures for the nerves; numerous delicate cells are connected with these, and such as are above and before the flat plates are lodged between the frontal and orbitar plates of the frontal above and the lachrymal and upper jaw-bone below; a pair of horizontal plates project forwards into the nostril, which join with corresponding twisting plates on the inside of the nasal processes of the upper jaw-bones. In the latter species the sieve-like plate is more of a pentagonal form, and only hollowed from below upwards, but not laterally; the crest is wider and flatter, and the small holes less regularly disposed; the convolutions are fewer in number and shorter, and there is scarce any trace of the projecting horizontal processes.

The Temporal bones, in the *Nine-banded Armadillo*, consist only of two pieces, the squamo-mastoid, which entirely excludes the petrous portion, except from the base of the Skull. The former portion is nearly square and thin: its upper scaly edge overlaps the parietal; its lower edge slightly notched forms the top of the tympanal aperture, before which stands out horizontally the square flat glenoid surface, and from its outer margin rises up vertically the short square zygomatic process. In the *Weasel-headed Armadillo* all the por-

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tions of the Temporal bone are consolidated into one; the back of the mastoid process fills up the gap in the edge of the occipital bone, and juts out, rendering the occipital surface of the Skull triangular, and its front forms the back of the external auditory passage, which is perfected by the tympanal bone, and to the inner end of this passage is placed the bony ear-drum; the squamous portion is low and long, and it sends obliquely outwards and downwards a slender flattened zygomatic process, the root of which is separated by a deep conical pit from the tympanal cavity, and has on its under face the glenoid surface. In the *Nine-banded* species there does not appear to be either bony auditory passage or drum, and the under surface of the petrous portion is in the macerated Skull exposed at the base.

The Parietal bones are narrow in the *Nine-banded* and wide in the *Weasel-headed* species, in accordance with the breadth of the Skull; and in the latter the hind edge splays upwards, to assist in forming the occipital crest.

The Frontal bones together are of an arched square shape, with a beak-like projection in front formed by the lengthening of the nasal processes, most in the *Nine-banded* species, between the upper jaw-bones. In both species there is considerable lateral contraction a little in front of the hind angles of the bone, which marks the extent of the temporal pits; and in front of these the bones bulge out for lodgment of the convolutions of the ethmoid bone, and to form the upper short margins of the orbits, the division between which and the pits is indistinct in the *Nine-banded* species, but in the *Weasel-headed* there is a well-marked posterior angular process. The frontal plates of the Frontal bones are generally flat, broad behind and before, but narrowed in the middle where forming the middle of the brow ridge, which indicates the position of the vertical ethmoidal gap.

The Lachrymal bones in the *Nine-banded Armadillo* have each a large triangular nasal plate: its base uppermost joins the frontal bone, its anterior edge with the upper jaw-bone, and the lower with the palate-bone; its orbitar plate narrow and triangular, with its base below resting on the latter bone, and its inner edge joining above with the frontal and below with the flat plate of the ethmoid bone. In the *Weasel-headed* species this bone is much smaller and is remarkably distinguished, being interposed between the inferior anterior angle of the frontal, the root of the malar process of the upper jaw-bone, and the malar bone, in a gap specielly left for the purpose.

The Cheek-bones (H.) in the *Nine-banded* species are deep, compressed, and curved downwards and forwards, the square hind extremity joining endways with the zygomatic process of the temporal, and the pointed front extremity being inserted between the lachrymal above and the short angular malar process of the upper jaw-bone below; the concave upper edge forms the lower margin of the orbit. In the *Weasel-headed* (fig. 20.) the Cheek-bone is much larger; its square hinder part is connected with the whole under surface of the zygomatic process of the temporal, and not with its extremity; its front or orbitar part bends suddenly inwards, and has its oblique lower edge joined to the malar process of the upper jaw-bone and to the lachrymal.

The Palate-bones are long and narrow: in the *Nine-banded Armadillo* the pterygoid processes are horizontally flattened, and curve upwards behind the corresponding processes of the sphenoid to their roots; but in the *Weasel-headed* species they are flattened laterally, and their upper edge hollowed to receive the convex edge of the pterygoid processes of the sphenoid, which extends down a little on their outer surface. In the former the greater part of the upper outer edge of the palate-plate joins with the ethmoid, and helps to form the temporal pit; but in the latter it runs withinside the alveolar process of the upper jaw-bone. In both the nasal surface of the palate-plate has a thin lengthy ridge, the upper edge of which sustains a pair of diverging thin leaves, which are connected with the ethmoid bone.

The Upper Jaw-bones (J.) are narrower in the *Nine-banded* than in the *Weasel-headed* species, particularly in front of the orbits: this depends on the absence, or rather small development, of the malar process in the former, which scarcely extends behind the lachrymal bone, and only by its tip touches the cheek-bone; but in the latter this process ($\rho$.) is very lengthy, and juts out considerably beneath the cheek-bone. In the former the palate-plate, thickened at its outer edge by the tooth-sockets, does not extend behind the junction of the bone with the lachrymal; but in the latter the tooth-sockets are continued far back, even into the temporal pits. At the junction of the lachrymal with the Upper Jaw-bone the latter protrudes externally, and a sort of lachrymo-maxillary cell, largest in the *Weasel-headed Armadillo*, is formed, communicating with the nose; and on the inside of the nasal process a long ridge supports the Turbinated bone.

The Muzzle-bones, in the *Nine-banded* species, have their nasal plates short, low, and convex externally, and the palate-plates flat, narrow, and the incisive hole in each very small. In the *Weasel-headed* the bone is deeper, its palate-plate wider, and the hind outer edge of the latter thicker, to lodge the root of a tooth.

The Nose-bones (L.) are lengthy, but wider in the *Weasel-headed* than in the *Nine-banded Armadillo*; they stretch beyond the front of the muzzle-bones and bend over the nostrils, so that the external nasal apertures are directed downwards instead of forwards.

The Lower Jaw consists of a pair of pieces united in front by a ligament; in all their proportions they are thickest and strongest in the *Weasel-headed*, but more slender and lengthy in the *Nine-banded* species; the condyles in both are concave, laterally in the latter, but from behind forwards in the former, and its hind lip much elevated. The teeth-sockets in the *Weasel-headed* extend almost to the very anterior extremity of the Jaw, but in the *Nine-banded* do not occupy more than its middle third.

The *Orycterope* is considered by Cuvier to have great resemblance to the *Giant Armadillo*; but the greater length of its face and breadth of its nasal bones, together with the development of the angular posterior orbitar processes, distinguish it from all other *Armadillos*, independent of its hairy instead of scaly covering, and other circumstances.

(* * *.) The Ant-eating Family, including the *Ant-eaters*, *Myrmecophaga* (Pl. IV., fig. 6.), and *Pangolins*, *Manis* (fig. 21.), are characterized by the thickness, length, and tubular form of the whole head; by the participation of the sphenoid bone in the formation of the floor of the nose; by the imperfect zygomatic arches and the little developed or deficient cheek-bones; by the slenderness of the lower jaw, and by the entire absence of teeth.

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The Occipital bone (A.) in the *Great American Ant-eater, Myrm. Jubata*, is remarkably thick and massive on its upper part; the occipital hole, large and oval, is longest transversely; its condyles are large and prominent but not lofty; the basilar process is very thin, and has the pterygoid processes of the sphenoid running beneath it, and joining with the paramastoid processes (Pl. V., fig. 14. a.), which are not very large, but flattened from behind forwards. The occipital part of the bone is the *Middle Ant-eater, M. Tamandua*, is vertical, but in the *Great Ant-eater, M. Jubata*, inclines much forward from above the condyles to the well-defined transverse parietal bones; from the middle of the transverse ridge descends to the occipital hole an indistinct vertical ridge.

The Occipito-sphenoidal portion of the Sphenoid bone joins the occipital, and is most remarkable in the *Ant-eaters*, as participating in the formation of the drum cavity of the ear; the Turkish saddle is wide but not deep, and the clinoid processes, though well defined, not tall; the spinous processes, stout and thick, stretch out, so that on each side a deep gap admits the wedging-in of the mastoido-petrosal part of the temporal between the Sphenoid and occipital. The temporal plates are short and little extended, but as frequently stretch before the anterior clinoid process on each side of the Ethmoido-sphenoid bone, and from the under surface of their roots descend the internal pterygoid processes, which, in the *Pangolins*, stretch backwards within and beyond the swelling ear-drums, and have each a long narrow aperture communicating with the drum cavity and probably the opening of the Eustachian tube. In the *Ant-eaters* the pterygoid processes reach back, as in the *Porpesses*, to the paramastoid processes, in which they terminate; their lower edges (fig. 14. b.) bend suddenly and horizontally inwards, to meet at the mesial line (except at a small posterior angular gap), and so lengthen backwards considerably the otherwise enormously-long nasal passages; a gap separates the front of these pterygo-palatine plates, so that the palate-bones are received within them, as well as connected to the front of the pterygoid processes, as usual. On the outer edge of each pterygoid process, opposite the origin of its palatine process, springs outwards and upwards to the outer under edge of each spinous process a large bulging triangular plate (e.), doubtless the external pterygoid plate joined by its lower edge to the internal, instead of being free; the ordinary pit consequently becomes a cavity, which may be described either as freely communicating with or forming the front of the drum cavity, of which the hinder part, or true drum, has the petrous portion of the temporal to its inner and upper side, and the squamous and tympanal portions on the outside; the latter (d.) of somewhat triangular shape, and bulging with its base uppermost, just below which is the round aperture around which the drum membrane is attached, but there is no external bony auditory passage. In the *Middle Ant-eater* the formation of the drum cavity is much the same, but an external contraction marks the extent of that portion formed by the sphenoid from that formed by the temporal bone. The Ethmoido-sphenoid bone connected with the ethmoid is small, its transverse spinous processes slightly outspread, and the portion of the bone appearing in the orbits little more than the margin of the optic holes.

The Ethmoid bone is of very large size: its cribriform plate is inclined obliquely forwards, in shape nearly resembling that of a heart on playing-cards, and forming the entire front of the cavity of the Skull; a middle vertical broad ridge divides the plate into lateral portions, and the whole is perforated with an immense number of very small holes which lead to the spaces between the convolutions; these are extremely numerous and delicate, and have their anterior ends resting against an oblique plate nearly parallel to the cribriform, and separating them from the general cavity of the nose, excepting some few apertures by which the air is admitted into them; the nasal process is very lengthy and wide above, and on each side of it, from the upper and lower edge of the plate already mentioned, depend two plates which correspond to the turbinated plates in the Human subject, and the lower pair are connected by the spreading base of the Ploughshare bone, which forms an arch between the nasal and these turbinated processes on each side.



As regards the remainder of the Temporal bone, the mastoidal and petrous portions form a single mass, and tightly wedged in between the spinous process of the sphenoid and the paramastoid of the occipital; a small part of the mastoid (c.) projects back between the paramastoid process and the tympanal portion, but the entire petrous portion is concealed by the hind under angle of the parietal bone and by the low squamous portion of the temporal, which completes the top of the drum, and is continued forwards, extending much inwards, to join the sphenoid from the tip of its spinous process to its temporal plate, and to assist largely in forming the floor of the skull, in which the middle lobes of the brain rest. In the *Pangolins* the drum cavity is large behind and below the external auditory aperture, and running inwards to jut against the pterygoid process, through which it communicates with the throat, as already mentioned; above and behind the mastoid portion (fig. 14. η.) swells out into a much larger cell than the drum with which it communicates. The outer surface of the squamous portion is vertical, low in the *Ant-eaters* (f.), but higher in the *Pangolins*: in the former it terminates in front in a short slightly hooked-down zygomatic process (ζ.), which has at the back and inside of its root the lengthy but scarcely concave glenoid surface; but in the latter (Pl. IV., fig. 21.) this process is of considerable size and thickness, square-shaped, with a slightly convex small articular surface facing downwards and inwards on its hinder inner part. Cuvier describes the sphenoid bone as assisting to form this surface.

The Parietal bones are of moderate size, thick, and form the arch of the Skull from the upper edge of one squamous portion of the temporal to the other, on which they rest without any overlapping; the hind edges rise obliquely upwards and forwards, and the gap thus formed receives the front angle of the occipital; the inferior anterior angle is interposed between the frontal bone and squamous portion of the temporal, bends inwards, and rests on the small temporal plate of the sphenoid, and behind it springs up from the lower to the front edge of the bone the curved temporal ridge, which projects beyond the front edge and laps over the frontal bone, which is the only part that can be called scaly, as all the other edges are thick and deeply indented.

The Frontal bones are of very great length, and the part specially elongated is that above their junction with the long lachrymal bones. The vault of the Skull still arches transversely throughout the whole length of the bones, as low on each side as the continuation of the

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temporal ridge, which now, however, ceases to give muscular attachment, and becomes the brow margin of the orbit, of which the cavity is extremely shallow, the Frontal bone only, as it were, slightly thrust into the cavity of the Skull, and the long orbitar plate of the palate-bone below forming its inside, and the orbitar plate of the lachrymal its front; it is entirely devoid of floor, unless perhaps the slight outward extension of the coronoid process of the lower jaw, which is immediately beneath, can be considered as forming it. The nasal processes are of considerable length, but are for the most part covered by the roots of the nose-bones; the long oblique anterior edges join with the upper jaw-bones, and the nearly horizontal edges between these and the orbits with the lachrymal bones. In consequence of the shallowness of the orbits, the orbitar plates form no part of the floor, but only the sides of the fore part of the cavity of the Skull, and consequently a very large gap exists between the frontal bones above and on the sides and the ethmoido-sphenoid below, which is filled up by the large ethmoid bone.

The Lachrymal bone in the *Ant-eaters* is lengthy, and consists of a pair of plates: the lower horizontal one runs inwards to join the outer edge of the palatine plate of the palate-bone, and assists it in forming the palate; the vertical plate arches inwards to join the broad angular process of the frontal bone by its facial surface, which is terminated behind by the orbitar surface, small and facing backwards as it joins the orbitar plates of the frontal and palate bones in forming the front of the orbit; a little prominent elevation separates the facial from the orbitar surface, before and at the root of which is the aperture of the nasal duct. In the *Pangolins* Cuvier denies the existence of any lachrymal bone; or, if it exist, that it is but extremely small. It does, however, exist, and is distinctly visible in a young animal of the African species in the Museum of the College of Surgeons; and in a nearly adult specimen it is also traceable, though anchylosed to the frontal bone.

The Palate-bones are of considerable length; the upper edge of their low orbitar plate joins the sphenoid frontal and lachrymal bones, and with them perfect the inside of the orbit. All that part, more than half, of the palate-plates in front of the orbitar are received within the palate-plates of the lachrymal and upper jaw-bones. In the *Middle Ant-eater* (Pl. V., fig. 15.) the hind part (d.) of each orbitar plate immediately in front of the pterygoid processes is remarkably swelled into an oblong vesicle, which communicates by a small aperture with the nostril of that side. In the *Pangolins* no such vesicle exists.

The Face is of considerable length in the *Great Ant-eater* (measuring from the front of the orbit), being two-thirds of the total length of the Head from the occipital condyles to the muzzle; but in the *Middle Ant-eater* and in the *Pangolins* it is scarcely half the length. It is of tubular form, but the palatine surface is flat; the long Nose-bones form the middle, and the facial plates of the Upper Jaw-bones (J.) the sides of the convex part; the latter bones lengthen backwards by an oblique edge (e.) each, which joins the frontal and lachrymal, and continuing below the latter closely connected with its front and lower edge in the *Middle Ant-eater*, but with the front edge only in the *Great Ant-eater* (Pl. IV., fig. 6.), overhanging and overlapping the lower jaw, somewhat as do the corresponding parts in the *Whalebone Whale*. These lengthenings must be considered as the malar processes, upon each of which is attached the corresponding Cheek-bone (N.), dagger-shaped, and tapering backwards to a point in the *Great Ant-eater*, but short, compressed, and deep, like the extremity of a broad sword in the *Middle species*. In both animals this bone continues back, forming the lower edge of the orbit, but it never crosses the temporal pit, nor reaches the short zygomatic process of the temporal bone. In the *Pangolins* there does not seem to be any Cheek-bone; or, if there be, it is consolidated at a very early period with the malar process of the Upper jaw-bone, which is in them short, triangular, and compressed. Upon the concave inner surface of the facial plate of each upper jaw-bone is attached a correspondently long and simply twisted Turbinated bone. In the *Ant-eaters* the Muzzle-bones (K.) are very short; their nasal plate, much arched and nearly vertical, joins the tip of the corresponding nose-bone, but their palatine processes are very slender, and do not reach back to the palate-plates of the Upper jaw-bones; consequently the incisive holes are not completely divided by bone, and in the *Great* species the front point of the ploughshare bone projects into it. In the *Pangolins*, on the contrary, the nasal plates are long, not upright, but inclined backwards, and separated from the tips of the Nose-bones (L.) by clefts; their palate processes are very long and slender, and continued between the front of the palate-plates of the upper jaw-bone. In these the incisive holes are very small, but in the *Ant-eaters* large.

The Lower Jaw in the *Ant-eaters* consists of a pair of lengthy, slightly downward curved, sword-shaped pieces, with the sharp edge uppermost, and occupying the place of the tooth-sockets; the lower edge is rounded, the external surface slightly convex from edge to edge, and the internal correspondingly concave; the hind part of the bone nearly rectangular, except at the top of the ascending branch, which projects horizontally backwards a narrow oblong articular surface or condyle, slightly arched transversely, and having at the fore and inner part of its root a little overhanging edge. In the *Middle* species there is a slightly elevated stumpy coronoid process in front of the condyle and on the upper edge of the bone; but in the *Great Ant-eater* this process inclines outwards, and is more lengthy. The front end of each bone tapers, but is rounded, compressed, and joined to its fellow by ligament. In the *Pangolins* (Pl. V., fig. 36.) the two bones are early united into one at their fore and under extremities; both lower and upper edges are sharp, and the latter just behind the front of the jaw has on each side a remarkable little sharp triangular spine (f.), as it were in place of teeth. The condyles are broad, flat, or slightly hollowed, and face upwards and outwards; the coronoid processes are scarcely developed, and the analogues of the angular processes near the middle of each have the ascending branches reclining at a very obtuse angle.

(a***.) The Monotrematous Family has such a peculiar form of Head as at first sight almost to remove them from the Class of Beasts; but a close examination will show that in all essential characters they really belong to this section of Vertebrate Animals. The early consolidation of the Skull-bones, especially into a single piece, which occurs so early in the *Ornithorhynque* that in almost every skeleton hitherto described the sutures have entirely disappeared, led Meckel to point this out as an analogy to the Skull of Birds. But this is no peculiarity; for many other Beasts, as the *Badger*, *Otter*, *Weasels*, &c., soon

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lose all trace not only of suture but also of harmony on the face. The only correspondence between these animals and Birds is in the form, not in the composition of the face; thus, the *Echidna* has the face resembling that of the *Apteryx*, whilst in the *Ornithorhynque* is recalled the flattened expanded shape of the beak of the *Spoonbill*.

The Occipital bone (A.) in the young Echidna (Pl. V., fig. 30.) is divisible into the usual four pieces, of which the basilar (a.), broad, thin, and hexagonal in shape, forms with the large articular pieces the occipital hole, and the lateral pieces lengthened backwards supprot the condyles (b. b.), each on a sort of low neck; the occipital piece is an oblong square, with its greatest length transverse. In the *Ornithorhynque* the angles are less prominent, less vertical, and in front of each, at the base of the Skull, is the very large transversely oval posterior lacerated hole. In both animals there is a slight external vertical crest; the upper edge of the occipital hole is deeply cleft, and the inner ends of the condyles join before its lower edge, but in neither is there any bony tentorium.

The body of the Sphenoid bone (fig. 30. a.) is, in the *Echidna*, more early united with the ethmoid than with the occipital bone; it is wide and lengthy, and the Turkish saddle is bounded on either side by a deep thin plate, passing from the posterior to the anterior clinoid processes. These plates descend below the body as the internal pterygoid processes, spread slightly outwards, and their lower edges resting on the palate processes of the palate-bones, which have no vertical pterygoid processes, form the sides of the back of the nostrils; a slender process (c.) from each pterygoid stretches back behind the palate beneath the junction of the basilar of the occipital and the petrous portions of the temporal bones, and to this is attached the upper ridge upon the external pterygoid process (d.), which, as Cuvier observes, extends the plane of each palate-bone, and is remarkable for being horizontal, or nearly so, and contributing in the formation of the tympanal cavity. Meckel also describes them as "completely separate, large, lying horizontally from before backwards beside the palate-bones, and, inclining behind their extremities, curve outwards in a hoop-like form." Owen considers them rather as "palatal plates contributed by the petrous bones to the posterior part of the roof of the mouth, which supports the bony palate-teeth." The opinion of Cuvier and Meckel that they are parts of the Sphenoid is to be preferred, inasmuch as a comparison with these parts in the *Porpesses* shows the lower part of the pterygoid process as here forming the hind external angular part of the palate, though comparatively in a smaller extent, with an obtuse angular gap between itself and its fellow, into which the conjoined angle of the palatine plates of the palate-bones projects, whilst in the *Echidna* the cleft is narrower and continued deeply between the palate-bones themselves. In the *Ornithorhynque* the Turkish saddle has neither side plates nor anterior clinoid process, but the posterior clinoid rises up like a double-pronged fork, and is remarkable for a pair of holes at its base. The inner pterygoid processes are much as in the *Echidna*, but more vertical; in neither of the College specimens are external pterygoid existent, though the conjoined edge of the internal and the palate-bone indicate their original presence. In the very slight description by Jaffe of the two *Ornithorhynques* in the Berlin Museum, it is stated that "the pterygoid processes of the Sphenoid bone in both Skulls remain distinct bones;" and the figure he gives represents them as much narrower than in the *Echidna*, and having the hind end curled outwards; they are also further apart, the hind margin of the palate-bones being straight instead of cleft, and much less of the hind outer angle of each palate-bone being truncated for its junction. Meckel also says that they are "perfectly moveable," and describes each as "a lengthy horizontal narrow plate, with its posterior extremity curving outwards, and situated on the lateral edge (of the palate) near its hind end." In the *Echidna* the temporal plates are small, low, and separated by the extension forwards of the squamous plates of the temporal from the parietal bone; but in the *Ornithorhynque* it is not possible to define their boundaries. On the fore and upper part of the bone a deep band of semicircular form seems, in the *Echidna*, to represent the transverse processes and the back of the ethmoidal gap; the ends of the band curving forwards and outwards appear in the common temporo-orbitar pit, forming the orbitar plates of the bone beneath and below the frontal bone, and the entire space between the concavity behind and the junction of the face with the frontal bone is entirely filled by the enormously large sieve-like plate (e. e.) of the Ethmoid, which is divided into three by a middle elevated portion, but the whole surface pierced with innumerable delicate apertures. In the *Ornithorhynque*, the olive process is as usual hollowed; the out-spreading of the transverse processes little; the ethmoid gap small; the sieve-plate of the ethmoid small also, and divided by a middle ridge into two shallow cavities, each of which is provided with but two, though large holes.

All the pieces of the Temporal bone (D.) except the tympanal are very early massed together into one, in both *Echidna* and *Ornithorhynque*. The mastoid piece (f.) assists largely in the formation of the back of the Skull, and its mastoidal process is slightly developed. The squamous piece (g.), commonly so called, is considered by Owen to be a large development of the petrous portion or bone, and he holds the broadly expanded root of the zygomatic process to be the true squamous portion. It is true that the petrous bone is very widely expanded, especially forwards (h.), to form the floor of the middle of the Skull, and the roof of the very spacious tympanal cavity in the *Echidna*, but this is no sufficient reason for considering the bony expansion between the mastoid process behind, the sphenoid bone before, and the parietal above, as extra-developed petrous bones; the position is that of the squamous piece, and a lengthy tongue runs from its fore and upper part across the top of the temporal plate of the sphenoid to the frontal, below which tongue is a gap separating it from that part of the petrous bone forming the floor of the Skull, and which is filled up or covered by the root of the zygomatic process, and so resembles the disposition of the squamous part of the temporal in Ruminant Beasts, which is almost entirely excluded from the cavity of the Skull by the parietal bone. The remarkable reptile-like double origin of the root of the zygomatic process, on which Meckel lays so much stress, is really no peculiarity; the hole which produces this appearance in the *Ornithorhynque* is observable in Ruminant Beasts, as already mentioned, winding, from before and below the glenoid process, over it to terminate in the lateral sinus. In the *Echidna* the root of the zygomatic process is much extended upwards and forwards, so that it



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partially covers the temporal pit, forming a narrow gap between itself and the side of the Skull, and in front it terminates in a needle-like projection (ζ.), which joins the malo-maxillary bone to perfect the zygomatic arch. In the *Ornithorhynque* the zygomatic process is deep, yet does not cover the temporal pit, but as usually continues forward nearly of the same depth to join the face-bones and perfect the zygoma. The glenoid cavity of the *Echidna* is very small and shallow, but in the *Ornithorhynque* is very deeply concave forwards. The under surface of the petrous piece (h.) is seen between the inside of the glenoid process and the pterygoid of the sphenoid, forming the inner upper part of the drum cavity, and has in it the openings of the labyrinth; it is separated from the cartilaginous auditory passage by the drum membrane, attached on the anterior inner and sometimes posterior part to a tolerably thick bony arch, probably the rudimentary tympanal piece; and within this Meckel describes the three bonelets of the ear. In the *Echidna* the under surface of the petrous piece is more indented into the Skull than in the *Ornithorhynque*, and forms a broadish pit behind the pterygoid process of the sphenoid, which actually forms a considerable part of the boundary of the tympanal cavity; three-fourths of the drum membrane is described by Owen as connected with the incomplete hooped tympanal bone (i.) with which the hammer bonelet (j.) is anchylosed.

The Frontal bones (a.), a pair, are of small size, but form the principal part of the vaults of the orbits; the posterior angular process in both animals, though small, is distinct, but does not join the zygomatic arch; the anterior joins the face-bones, and is not distinguishable.

The crown of the Skull is formed by the Parietal bone, which is of a polygonal shape in the *Ornithorhynque*, and remarkable for the bony scythe-like process which descends from the under surface, dividing the upper part of the cavity of the Skull into two lateral halves. In the *Echidna* this process is deficient, and the bone itself, instead of being angular, is roundish, like a priest's skull-cap, and overlaps the edges of the occipital and frontal bones, and of the squamous portions of the temporal.

The Cheek-bone generally is not distinguishable as a single bone in the zygomatic arch, on account of its early anchylosis, as observed by Meckel; but Cuvier speaks of it as "a very small thread between the zygomatic processes of the temporal and upper jaw-bone" in the *Echidna*, with the latter of which it is specially connected; but it underlaps the former, like it being very slender, and is only connected with it by ligament. In the *Ornithorhynque* the three bones are all anchylosed together; the zygomatic arch is very long and deep, and the posterior orbitar process of the cheek-bone is well defined, as also the lower margin of the orbit.

The palate-plates (k.) of the Palate-bones of both *Echidna* and *Ornithorhynque* form a considerable part of the back of the palate: in the former, they together assume an unequal-sided hexagonal shape; the anterior angle projects between the palate-plates of the upper jaw-bones; and the posterior, which is deeply cleft, stretches back between the external pterygoid processes of the sphenoid bone. In the latter, the palate-plates together are of an oblong square form, and their hind and front ends being straight, instead of angular, diminish the extent of the pterygoid processes of the sphenoid and the palate-plates of the palate-bones. The internal pterygoid processes descending to form the sides of the back of the nostrils, the Palate-bones have not any nasal processes, and it is difficult to determine how much they participate in the formation of the orbitar cavity.

The upper Jaw-bones in the *Echidna* are very simple, consisting each of a nasal and palatine plate, which taper from the Skull to the muzzle; the former is low and the latter narrow; their outer edges uniting form the principal part of the margin of the jaw, but sustain no teeth; its hind end lengthens backwards into a tapering process, which runs beneath the zygomatic of the temporal, and is the representative of, if not actually, the anchylosed cheek-bone: the nasal process joins behind with the frontal, and either sends a process into the orbit, occupying the place of the lachrymal, or that bone is anchylosed also to it, and its situation marked by a hole held to be the nasal duct; the palate-plates have behind the palate-plates of the palate-bones interposed between them, and in front they are separated by a cleft, forming the back of the large single incisive hole. In the *Ornithorhynque* the upper jaw-bone is very flat and shallow; it is very remarkable, however, for the broad concave process which lodges the horny teeth, and runs beneath the presumed junction of the upper jaw and cheek bones, and stretches inwards to the palatine plate, so that it forms above the floor of the orbit; the infra-orbitar holes are very large, situated on the middle of the side of the nasal process, and between the front of those processes and the wide palatine processes are received the hind ends of the muzzle-bones.

The upper surface of the Face, between the frontal bones and the anterior aperture of the nostrils, is occupied by the Nasal bones, long, narrow, and arched laterally in the *Echidna*, but shorter, flatter, and wider in the *Ornithorhynque*, in which they form the hind margin of the nasal aperture, though not so in the *Echidna*.

The Muzzle-bones, of correspondent form with the upper jaw and nose bones, form in the *Echidna* the entire nasal aperture, their nasal plates meeting some distance before the nasal bones, then diverge, and are lost on the narrow palate-plates, which curve inwards and forwards to form the front of the large incisive hole, of which the palate-plates of the upper jaw-bones form the back. In the *Ornithorhynque* the Muzzle-bones are flat, and project forwards and outwards from between the nose and jaw-bones, so as to widen the muzzle very considerably; they then curve forwards and inwards, but do not meet, and a large gap is left between them and the palate-plates of the upper jaw-bones below and above. The bones just mentioned are considered by Meckel as merely one part, the facial part of the Muzzle-bones, of which the other or palatine part is represented by a single figure-of-8-shaped bone; not, as he says, connected by the membrane of the mouth to the front of the palate-plates of the upper jaw-bones, but to the tip of the plough-share bone by cartilage, to which it probably really belongs, and corresponds to its extremity, appearing in the palate of the Porpesse Tribe, for there is no appearance of any such palate-plate in the *Echidna*, nor any division of the incisive hole into two.

The Lower Jaw consists of a pair of branches: these in the *Echidna* are very simple, being mere styles tapering from behind forwards, and curving a

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little inwards; the condyle, coronoid process, and angle are all distinct, though slightly developed, and the condyle placed far behind the angle. In the *Ornithorhynque* the branches are bulky, the condyles convex, and facing backwards and upwards; the part occupied by the horny tooth is of an oblong form; behind it the bone has a somewhat cylindrical form, lodges on its outside a deep conical pit, and has on its inside the large posterior maxillary hole, of which the canal runs beneath the teeth; the coronoid process, as a little stud, projects above this hole: in front of the tooth the jaw-branch is at first compressed, and inclines inwards to meet its fellow, but having done so it becomes depressed and divergent, so that the extremities of the two branches are separated by a V-shaped gap.

(F.) The GNAWERS generally have the back of the Head vertical; the occipital hole large, and its upper edge interrupted by a gap; the hinder part of the squamous portion of each temporal bone lengthening into a thin narrow slip, which runs above the auditory passage to the mastoido-petrosal piece; the zygomatic process of the same bone descending short, flat, and triangular, and the glenoid cavities lengthy from behind forwards; the cheek-bones large, and in some instances enormous; the muzzle-bones with large sockets for the constantly growing incisive teeth.

In the Occipital bone the great hole is an oblong square, of which the longest diameter is transverse, and not unfrequently, as in the *Rabbit*, is there a gap, of varying size and shape, in the upper edge; the condyles, compressed and tall, reach as high as the upper edge of the occipital hole, and their articular surfaces are much extended externally; the basilar process is generally very wide, and not unfrequently united in front with the body of the occipito-sphenoid. The occipital surface of the bone is irregularly flat, vertical, and bounded by the arched occipital ridge, from the middle of which descends to the occipital hole a more or less distinct sharp vertical ridge, and at its front the upper part of the bone bends downwards, becomes parallel with the basilar process, and either projects in an angular form between the parietal bones, as in the *Porcupine*, or squarish and not separating those bones, as in the *Rabbit*, *Guinea-Pig*, &c.; on the contrary, in the *Squirrel* and *Rat* there is scarcely any projection in front of the ridge, and then only at the outer edge, so that in the *Squirrel* the Occipital and parietal bones join at once by a straight edge, but in the *Rat* an oblong somewhat triangular bone, which, however, is really part of the Occipital, is interposed. The paramastoid processes are very various: in the *Squirrel* they are very small and delicate, but in the *Guinea-Pig* of great length and flattened from behind forwards; upon their front rest the mastoido-petrosal pieces of the temporal bones, which also, in a greater or less degree, assist in the formation of the back of the Skull, a large gap existing between the root of each paramastoid process and the projecting upper part of the Occipital bone for their lodgment.

The Sphenoid is sometimes a single independent bone, as in the *Porcupine*, and at other times consists of an Occipital and an Ethmoidal portion, which are either distinct pieces, as in the *Rat* and *Guinea-Pig*, or the occipital piece is consolidated into one with the occipital bone, but the ethmoidal still remains separate, as in the *Rabbit*, *Squirrel*, &c. In the *Porcupine* the body of the bone is very wide, but narrows in front; the Turkish saddle is a nearly circular hollow, but the clinoid processes are not very distinct; the temporal plates are large, outspread, and but little curved upwards; the internal pterygoid processes are very deep, and their hooked hinder extremities curve backwards and upwards to join the under part of the ear-drum, and form small bony loops; their front edges are received within the hinder edges of the pterygoid plates of the palate-bones; the outer pterygoid plates descend from the under side of the temporal plates, are of triangular shape, and their inferior point joins the outside of each palate-bone and a very large deep passage is formed between the two pterygoid plates on each side instead of a pit. The transverse spines are flat, squarish, and their hinder joining the front ends of the temporal plates; from their outer edge descends the small orbitar process, and cells are formed between them, which are separated by the projection forwards of an ethmoidal spine. In the *Beaver* the loops (Pl. V., fig. 16. a.) of the internal pterygoid plates are larger than in the *Porcupine*, and the outer plates commence by double roots, one close to the inner, and another further out from beneath the temporal plate, with an intermediate small passage between; they soon join and form the single plate which curves outwards, so that a pit is formed between the two pterygoid plates. The *Rat* has the body of its Occipito-sphenoidal bone wide, square, and without any Turkish saddle, and a lengthy square process stretches forward from its front to join the Ethmoidal portion; its square temporal processes face almost directly forwards, and really form the bottom of the back of the orbits, excepting a small portion contributed by the short triangular transverse spinous plates of the Ethmoido-sphenoid, which are connected on their inner edges to the oblong piece stretching back to join the Occipital portion. The pterygoid processes consist of two plates, the inner very short, the outer long and triangular, with a passage or hole at their root and their front joined to the palate-bones. The *Guinea-Pig* has not any Turkish saddle, but the body of the bone is cellular instead; its temporal plates face outwards, and its transverse spinous processes assist in forming the back of the orbits; its outer pterygoid processes have double roots, and the passage between them is comparatively larger than in the *Porcupine*. The temporal plates in the *Squirrel* are very large, and curve much upwards in assisting to form the temporal pits; their front edge inclines forwards and inwards, and, with the triangular transverse spinous processes, contribute to the back of the orbits. In the *Rabbit* the temporal plates have two distinct surfaces, a small outer one, which assists in forming the temporal pit, and a larger front one at the bottom of the back of the orbit; the pterygoid processes are lengthy and narrow, and each pair of plates separated by a deep pit. The Ethmoidal portion has its transverse spinous processes wide, deep, vertical, and forming a large open angle backwards towards the cavity of the Skull; their upper edge joins the temporal plate of the frontal, and their lower the front of the same plate of the Occipito-sphenoid on each side. In front of the processes just mentioned project another pair of plates, less deep but longer, and diverging forward at an acute angle, between the frontal above and the palate-bone below, to the upper jaw-bone; they form large portions of the inner walls of the orbits.

The Parietal bones are sometimes flat upon the crown



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of the head, and suddenly bent down at the sides above the mastoido-petrosal parts of the temporal bones, as in the *Rats*, or they are gently arched, as in the *Squirrel*, *Guinea-Pig*, and *Beaver*. Their conjoined hinder edge is sometimes straight, as in the *Rabbit*, *Squirrel*, &c., in which case the temporal ridges commence separately, or the edges are oblique, so that an angular gap is formed at the junction of the bones, in which is admitted the projecting angle of the occipital bone, as in the *Porcupine*, and then the temporal ridges arise together from it and diverge as they stretch forward. In both these examples the ridges are little distant, and the temporal pits large. But in the *Rats* the ridges very far distant run almost straight forwards from the occipital ridge to the orbits, forming a spacious square surface on the crown, uncovered, except by skin, with low temporal pits beneath.

The Frontal bones have their frontal plates generally as wide before as behind, but in the *Rats* they are narrower, and in the *Porcupines* and *Beaver* wider in front; the hind edge is straight, but the front varies: in the *Porcupine* each bone projects an angular nasal process between the upper jaw and nose-bone, consequently a gap exists between these processes in which both nose-bones are received: in the *Guinea-Pig* the gap and processes are but little developed, whilst in the *Squirrel* they entirely disappear, and in place of the gap each bone projects its nasal process from the front inner point and does not by it separate the nose and upper jaw-bones. The inner edges, by which the bones join each other, are, as usual, straight; but the outer are more or less concave outwards and downwards, to form the upper edges of the generally common orbitar and temporal pits of each side; in the *Beaver*, however, the proper brow-ridges only are formed, the posterior angular processes being just indicated, but the anterior are very distinct. Into these brow ridges run and terminate the temporal ridges, and the slight projection then formed is sometimes, as in the *Porcupines*, *Guinea-Pigs*, and *Rats*, the only trace of posterior angular process; nor is the anterior more distinct. But in the *Squirrel* the brow ridge is much arched, and the posterior angular process well developed and standing out from between the temporal pit and orbit. The *Rabbit* is remarkable for the great narrowing of the middle of the bones in an angular form, from which juts out the hatchet-shaped brow margin (Pl. IV., fig. 22. a.), the posterior angular process separated from the temporal ridge by a deep cleft, and the anterior from the ridge by the deep supraciliary notch. The orbitar plates, like a pair of concave triangular pieces, pass downwards and inwards, sometimes united below at their tips beneath the ethmoid bone, so as to render the ethmoidal gap a perfect hole, as in the *Rabbits* and *Rats*; in the *Guinea-Pig* the tips are just asunder, and in the *Squirrel* still further, but only slightly apart. This close indrawing of the lower ends of the orbitar plates produces two irregular triangular cavities, of which the truncated lips meet in the ethmoidal gap: the hind one forms the front of the cavity of the Skull, perfected below by the sphenoid bone; the fore one includes the ethmoid bone, and its lower edges rest on those of the orbitar plates of the palate-bones.

The size of the Ethmoid bone, at least as to breadth, is indicated by the width of the space between the orbitar plates of the frontal bone, but it projects more or less forwards beneath the nose-bones and between the nasal processes of the upper jaw-bones. The sieve-like plate corresponds in shape with the ethmoidal gap between the frontal and sphenoid bones; generally it is of a triangular form with the base uppermost, but in the *Porcupine* is more oval, with the long diameter transverse; it is more or less deeply concave backwards, and the upper angles often lengthened into a pair of horns, which strengthen its connexion with the frontal surface of the frontal bone; its plane, as regards the ethmoidal gap, is not parallel to it, but its upper edge is inclined considerably forward, consequently there seems to be a deep pit between it and the general cavity of the Skull. A vertical ridge generally divides it into two parts; this is extremely large in the *Porcupine*, but in the *Rat* is deficient; it is variously developed in the *Rabbit*, *Squirrel*, and *Guinea-Pig*, but in all these is rather an elevation than a distinct projecting ridge, and it contains two vertical rows of nervous holes. The convolutions, though occupying a large extent, are not very numerous nor complicated; sometimes a pair longer than the rest, as in the *Porcupine*, *Rabbit*, and *Guinea-Pig*, stretch further forwards into the nostrils. The uppermost convolutions have their upper edges united with the frontal and orbitar plates of the frontal bone, so as to form cells; and the undermost communicate with the cells in the upper jaw-bones. The partition plate descending from the bottom of the cock's-comb is, as usual, joined to the ploughshare bone.



The several portions of the Temporal bone are, with the exception of the squamous, which always remains distinct, consolidated into one mass, of which appear externally only part of the mastoid in the gap on the edge of the occipital bone, perfecting the back of the Skull, and interposed between it and the large drum vesicle (a.) which is situated at the side of the basilar process and depends considerably below it, sometimes without any bony external auditory passage, as in the *Rats*, sometimes with one, as in the *Guinea-Pig* and *Rabbit* (Pl. V., fig. 31. A.), in which latter kind it is remarkable for projecting upwards instead of outwards, and consequently the passage to the drum membrane runs downwards instead of inwards. The squamous portion has its vertical part (b. b.*) of considerable length from behind forwards; sometimes, as in the *Porcupine* and *Rats*, lapping on the side of the occipital behind and of the frontal before; sometimes, as in the *Squirrel*, only lapping on the occipital, but in front not reaching the frontal bone; and sometimes, as in the *Rabbit* kind, joining the frontal bone, but behind lapping only on the side of the mastoid portion. The hinder half of the vertical piece is shallow, especially in the *Rabbit* (b.*), but deep in the *Squirrel*; it runs back above the drum aperture, to terminate either on the mastoid portion or on the occipital bone, but does not appear at all in the cavity of the Skull. The anterior half (b.) is generally of a squarish shape: its upper nearly straight edge generally becomes scaly in front and overlaps the inferior anterior angle of the parietal, and its front edge not unfrequently the frontal bone also; the lower edge, indented, is received on the upper edge of the spinous process of the sphenoid. The most remarkable circumstance about the bone is the glenoid cavity, which consists of a long groove, transversely concave and facing downwards, formed by the jutting out of the glenoid process (c.) from the side of the squamous portion. From the outside of the glenoid descends the short triangular zygomatic process, the whole lower

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delicately indented edge of which rests on the cheek-bone: its front angle, in the *Porcupine* and *Rat*, is a mere point, but in the *Rabbit* (ζ.) and *Squirrel* is of greater length.

The Palate-bones (M.) vary considerably in regard to their horizontal and vertical plates. The former, or palate-plates, are, in the *Porcupine*, square, and project into the palate between the hinder tooth-sockets of the upper jaw; in the *Beaver* they are more triangular, but their tip projects similarly: in both the hind edge of the bones is straight. In the *Guinea-Pig* these plates are mere slips, continued within the triangular gap between the hinder tooth-sockets. In the *Rabbits* (Pl. V., fig. 31: a.) they run forwards, inwards, and meet at the back of the palate processes of the upper jaw-bones. The vertical plates sometimes extend largely into the orbits at the back and under part of their inner wall, as in the *Rabbits*, so as almost entirely to shut out the upper jaw-bone. In the *Guinea-Pig* and *Squirrel* they are also there found, but smaller; whilst, on the contrary, generally, as in the *Porcupine*, the orbitar plates of the frontal and upper jaw-bones shut them entirely out of the orbits, and they only exist at the bottom of the temporal pits.

The Cheek-bones (Π.) form almost entirely the zygomatic arches, and vary considerably in size and in outward and downward curving. In the *Paca*, *Cœlogenys*, and also in the *Capybara*, *Hydrochœrus*, it is short and deep; but is very thin in the *Dormice*, *Myoxus*, and the *Hamster*, *Cricetus*. In the *Rats* it is slender, curves much outwards, is convex downwards, and concave above. In the *Porcupine* it is nearly straight, short, thin, not very deep, but deepest in front. In the *Rabbit* it is thin, lengthy, and of a shallow triangular shape, the hind angle underlapping the zygomatic process of the temporal bone, and the front one the malar process of the upper jaw-bone; the upper slightly elevated angle is the posterior orbitar process. In the *Beaver* the front of the bone sends up, at right angle with the zygomatic arch, a broad process, the top of which forms the lower margin of the orbit. The junction of the Cheek-bone in front varies: in the *Porcupine* it joins vertically and endways with the malar process of the upper jaw-bone; but in the *Rats* it overlaps that process, and, when thus overlapping, commonly runs along the edge of the orbit till it arrives at the lower edge of the lachrymal bone.

The Upper Jaw-bones are deep in proportion to their length, and have the sockets for the grinding teeth, which they alone contain, generally largely developed, and forming the principal part of each bone. With but few exceptions, the sockets rise up as more or less prominent rounded ridges, which run along the inner under part of each orbit back into the temporal pit, forming the outer hinder wall of the nostrils, as in the *Rabbit*, *Rat*, *Beaver*, *Guinea-Pig*, in all of which the molar teeth continue growing throughout life, and the ridges are deep; but in others, as the *Squirrel*, whose molar teeth, once formed, grow no more, the tooth-sockets are comparatively shallow. In the *Porcupine* no ridge is discernible, as the interval between it and the frontal bone consists of the numerous cells with which the Upper Jaw-bone is furnished. The tooth-sockets are situated either in parallel two rows, as in the *Rats*, *Rabbits* (Pl. V., 7. a.), *Porcupines*, and *Squirrels*, in which case the palate, formed principally by their palate processes, is an oblong square; or they approximate in front, as in the *Beaver* and *Guinea-Pig*, so that the palate is narrower before than behind, and in the latter animal triangular, the sockets meeting anteriorly at an angle. The *Guinea-Pig* is also remarkable for the inward inclination of the hinder part of the socket-ridge to its fellow, so as to form a perfect arch over the back of the nasal passages, upon which the frontal bone rests. The palate-plates vary in size: in the *Porcupine*, *Rat*, and *Squirrel*, are lengthy and oblong; in the *Guinea-Pig* and *Beaver*, triangular; but in the *Rabbits* (r.) form only a very narrow bridge, the palatine gap behind being very large, as is also the incisive aperture in front. The nasal process generally consists of a pair of plates, the outer thicker one forming the side of the face, and the inner thinner one the wall of the nostril, between which are numerous more or less complicated cells, some connected with the ethmoidal, and others communicating directly with the nose; these are well seen in the *Porcupine*; not unfrequently also at the front end is the bottom of the socket for the large incisive tooth-pulp. In the *Rabbits* this process is little more than a bony outline, of which the filling up is membranous. The malar process is of considerable importance, as upon its greater or less projection outwards depends principally in this Order the extent of the temporal pit. In the *Rabbit* it is thick, short, and stands directly outwards; in the *Beaver*, and also in the *Squirrel* (Pl. V., fig. 12.), it inclines outwards and backwards, is very deep, wide, and triangular, with its base upwards, and the infra-orbitar hole (γ.) is small. In the *Porcupine* and *Guinea-Pig* (fig. 13.) it rises by a pair of branches, the upper (α.) from the top of the nasal process, very large and trigonal in the *Porcupine*, but very thin and slender in the *Guinea-Pig*; the lower branch (β.), from the root of the front tooth-socket, very large and deep in the latter, but slender in the former animal; the two branches incline outwards and backwards, the upper descending to join the lower, and with it form in front a very large irregularly triangular infra-orbitar hole (γ), and behind it the single deep process for its junction with the cheek-bone. In the *Rat* the root of the lower branch is broad and wide, and it rises up to meet the descending branch; the hole is comparatively smaller. In the *Paca*, *Cœlogenys*, the malar process is of so great size and depth as to cover and descend below the base of the lower jaw; in the *Capybara*, *Hydrochœrus*, it is still deep, but only reaches a little below the level of the under tooth-sockets. Generally the Upper Jaw-bones project little before their malar processes, and their edges joining the muzzle-bones vertical, or even inclined slightly backwards and downwards. In the *Rabbits*, however, the nasal process is much prolonged and of a triangular shape, with its base behind and its truncated apex in front.

The Muzzle-bones (K.) in this Order are the largest throughout the whole Class of Beasts, and together with the nose-bones form the narrow wedge-like projecting part of the face before the outstretching malar processes of the upper jaw-bones, upon which depend the remarkable width of the back of the face. The vertical or nasal plate is the largest and most important part of the bone; it is of considerable depth, and of irregular quadrangular form, but the hind edge is always longest and the front one shortest; externally it is more or less flat, but the upper edge inclines horizontally inwards to join the outer edge of the nose-bone, and the lower edge rounds in to join the palate-plate, which with its

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fellow forms a long laterally convex space devoid of teeth between the molar teeth of the upper jaw-bones and the large incisive teeth, the sockets of which, opening in front, curve upwards and backwards within the nasal process, and not uncommonly run back into the upper jaw-bones, as already mentioned. The incisive holes (σ.) are generally mere slits perfected by the muzzle-bones, *as in the Squirrel, Rat*, &c.; but in *Rabbits* (fig. 31.) though slit-like, they are wider. Sometimes the upper hinder angle of the nasal plate is continued as a long thin process between the nose and upper jaw-bones, as in the *Guinea-Pig*, and more especially in the *Hares*, on account of the length of their maxillary nasal plate.

The Lower jaw has its horizontal branches united at an acute angle; their hinder part, concealed partially by the corresponding ascending branches, are of considerable thickness and depth, for the lodgment of the large squarish molar teeth, the apertures of the sockets for which generally, as in the *Rats*, and still more in the *Guinea-Pig*, and other *Cavies*, are inclined inwards, so that the plane of the crowns of the teeth have the same direction, and overhang less or more the space between the branches; in the *Hare* kind, however, their plane is nearly horizontal, and the teeth consequently upright. The depth of the hind part of these branches depends on the sockets for the roots of the incisive teeth being continued backwards beneath the roots of the molar sockets; but their front is much shallower, the incisive sockets projecting forwards like a step, and continuing the junction of the branches before their angular union, in a square form with rounded edges, to their extremity, at which the apertures of the tooth-socket of each opens on a vertical plane. The incisive sockets are either lengthy, and continued nearly horizontally forwards, with a slight upward inclination, as in the *Hare* kind, or they are shorter and curve more or less suddenly upwards, as in the *Guinea-Pig, Rat, Beaver*, &c., and upon the curve which they have depends the projection or upper curving of the incisive teeth. Generally a horizontal ridge, more or less distinct, runs along the outside of this branch to the root of the condyle; it is slight in the *Rats*, but in the *Guinea-Pig* of very considerable size, and, jutting out with an ascending lip, produces a long and deep groove between itself and the outside of the branch. In the *Rabbit*, however, it is entirely deficient. The ascending branches form a very considerable portion of the expanse of the bone, depending principally upon the large size of the angular processes. In the *Hare* kind this branch is very tall, and springs up immediately behind the last molar tooth; its angular process is large and rounded, but does not stretch far behind the back of the condyle, which at the very top of the branch is compressed, of a lengthened triangular form, with its base in front, convex from behind forwards and transversely; below it is the coronoid process, merely a small angular projection of the front edge of the branch. Generally, however, the front of the ascending branch springs from the outside of the horizontal, commencing as far forwards as the second molar tooth, and then rises upwards to terminate in the coronoid process, which varies considerably in size and direction; in the *Guinea-Pig, Capybara*, and *Coypu Rat* it is triangular, very small, and immediately on the outside of the last molar, and a long shallow gap separates it from the low and compressed condyle, of which the articular surface is lengthy from behind forwards, and convex transversely, to suit the long narrow articular surface of the temporal bone. In the *Rats* it is much lengthened and curved backwards over the root of the condyle, which stretches backwards, nearly horizontal, and has its articular surface on the upper hind edge. In the *Beavers* the branch is tall, the coronoid process hooked back over the deep concavity separating it from the large square condyle, which is convex from behind forwards and transversely. The angular process varies considerably in the *Beaver*; it is rounded, and stretches back but little behind the condyle; in the *Rats* it is more angular and distinct; in the *Guinea-Pig* it projects back like a sword-point, and is nearly one-fifth of the whole length of the bone; but in the *Water Rat, Arvicola*, it is very sharp, and its lower edge inclines horizontally inwards. The base of the jaw is generally rounded, and becomes thinner and thinner to the extremity of the angular process, and its inner edge is more or less disposed to curve inwards; but in the *Coypu* a remarkable horizontal ledge also stretches from its outer edge, producing an appearance very similar to that in the lower jaw of the Marsupial Beasts.

(G.) The Marsupials or Pouchbearers, characterized by the pouch attached to the lower part of the belly, in which their young are fully developed and carried for some time after delivery, include various forms which represent or have a close analogy to other Orders; thus the tribe of Kanguroos is the representative of the Ruminators, those of Opossums and Dasyures are the analogues of the Flesh-Eaters, and the Wombats perhaps of the Gnawers. The most remarkable peculiarities in reference to their Head, are —the great depth and size of the zygomatic process of the cheek-bone, and the participation of its hinder end in the composition of the articular surface for the condyle of the lower jaw, to which also the spinous process of the sphenoid bone generally contributes; the swelling out of the back of the latter process into a bony vesicle, itself to form, or to aid in the formation of the drum cavity of the ear; the large apertures in the back of the palate between the palate and upper jaw bones; the contraction of the frontal bones in the temporal pits; and the large lateral expansion of the angular processes of the lower jaw, forming on each side of the roots of the ascending branches a large horizontal pit.

(*.) The Long-footed or Grazing Family includes the *Kanguroos, Macropus* (Pl. V., fig. 33.), and *Kanguroo Rats, Hypsiprymnus*, which feed on grass.*

Their Occipital bone has much resemblance to that of the *Sheep*; the occipital hole is large and oblong, with its greatest extent transverse, and a deep notch in its upper edge: its basilar process wide and stout: the condyles are nearly vertical, and their top on a level with the upper edge of the occipital hole: the paramastoid processes are stout, and compressed from behind forwards: the occipital surface is vertical and lofty; the crest not very strongly developed, and the bone in front of it curved forwards as a deep squarish plate, interposed between the hind plate of the parietal bones, and forming the beginning of the broad flat track, which is continued from the occipital crest onwards to the nose.

The Sphenoid bone (n.) has the body of its occipital portion very long, thick behind and thin in front; the

* The description is from the *Great Kanguroo*.

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Turkish saddle has no posterior clinoid process, but its sides are bounded by an elevated edge: the temporal and orbitar plates are large, so that the cavities for lodging the middle lobes of the cerebrum are very capacious: the temporal plates rise up between the temporal and frontal bones in the temporal pits; the spinous processes (η.) are little developed, but between each and the corresponding temporal plate (θ.) is a wide concavity (φ.), with a deep depending lip, upon which rest those parts of the temporal bone which form the fore and under part of the drum cavity. The plane of each outer pterygoid process (a.*) is transverse; its outer edge, thick and rounded, is at the lower end expanded backwards and forwards, and rests on the pterygoid process of the palate-bone; its inner edge also expands forwards and backwards; and a wide pit is formed in the process itself both in front and behind. The internal pterygoid processes are distinct bones, T-shaped, and very similar to those of the *Sheep*, but their surface broader, and instead of a hook process a narrow deep cleft extends throughout nearly the whole length of their hinder edge; their outside and front edge join the inner edge of the outer pterygoid process, so that between the two is produced behind a very large angular pit. The ethmoido-sphenoid portion is intimately connected to the ethmoid bone; its transverse spine is triangular, and overhangs the alive process.

The Ethmoid bone has its sieve-plate set obliquely, and far forward between the frontal bones; its convolutions are numerous, and project freely into the nose; the partition-plate is of great size, nearly square, and protrudes far before the convolutions.

The Parietal bones, a pair, have their flat coronal surface separated from the bulging temporal surfaces by the slightly elevated temporal crests, below the front of which, each bone projects a sharp thin process, overlapping a considerable portion of the corresponding temporal plate of the frontal bone, and forming a large square gap; the front lower angle joins the temporal plate of the sphenoid.

The Temporal bones are generally divisible into distinct portions. The squamous portion (D.) has its scaly plate (a.) small and semicircular; the glenoid process does not stretch far outwards, but the articular surface (ρ.) upon it is nearly flat, large, and triangular, with its tip in front and its base behind, bounded externally by a little bony stud (b.), and within by the outer edge of a nearly vertical oval plate, which forms the front of the ear-drum, and has its lower margin resting in the concavity at the hind end of the sphenoid bone, between its spine and temporal plate. The zygomatic process (a.*) is thin, very deep, and stretches forwards and a little inwards, so that the width of the temporal pit is not great. The mastoid and petrosal portions (f.) are consolidated into one, and the former assists in the composition of the back of the Skull. The tympanal portion consists of two pieces,—the external auditory passage or tube (e.), which runs inwards and downwards to the drum cavity, of which the front, formed by the oval plate of the squamous portion, and the back and upper part by the petrous bone, is perfected at bottom by the internal concave piece (d.), which is hollowed both from behind forwards and from side to side, with the aperture of the Eustachian tube at its inner hinder edge; its front, joining the sphenoid bone, is early anchylosed to it, and hence that bone has been held to assist in forming part of the drum, which certainly it does not: from the under face of this, the true drum piece, descends a triangular plate (e.), hollowed behind, into which is received part of the paramastoid process.

As to the Frontal bones, their frontal surface is long and flat; a large portion of the temporal plate being overlapped by the parietal bone, only a very small part appears externally in the temporal pit. The lateral contraction of the bones to form the ethmoidal gap is about their middle, and within the orbits. There is no appearance of angular processes, and the temporal pits and orbitar cavities communicate freely.

The Cheek-bones (H.) are deep: their upper large concave edge forms all the lower and front margin of the orbits, excepting the small portion furnished by the lachrymal bone; an angular gap separates the posterior orbitar from the zygomatic process; the former, scaly, is lapped against by the zygomatic process of the temporal bone, which is supported throughout its whole length by the latter, whose hind extremity (ν.) is continued to the articular surface, the front of which it perfects: the internal orbitar process is developed as a concave broadish band: the maxillary process is large and oblique, and its lower edge projecting downwards as a point.

The Upper Jaw-bones (I.) are long; their malar process is of considerable extent, juts well out from the external surface of the bone, and projects outwards and downwards as a distinct stud (τ.), overhanging the lower jaw. More than half the rank of tooth-sockets is, behind this process, of a square shape, and forming the floor of the orbits; a small elevated portion rises in front, separating the orbitar plate of the palate from that of the lachrymal bone. The nasal plate rises up vertically but concavely as high as the junction of the cheek and lachrymal bones, and thence obliquely upwards and inwards to join the long nose-bones. The palate-plates, long and narrow, are deeply gapped behind for the palate-bones.

The Lachrymal bones have narrow nasal but large oval orbitar plates, which, facing backwards and a little outwards, deepen the orbit considerably.

The Palate-bones (M.) are large; of their square nasal plate only the upper anterior triangle is apparent in the orbit, the lower hinder one being connected with the inside of the lengthened upper jaw-bone: the palate-plate is large and square, and has not any large hole.

The Muzzle-bones have their nasal plate very deep, and its lower front edge sustains teeth; the palate-plate is formed partially by the inward turning of the nasal plate and in part by a thin deep knife-like process, between which in front is a small oval incisive hole.

The Turbinated bones are lengthy but not complicated, and the Ploughshare bone is lengthy, curved low, and connected only with the front of the palate-plates of the upper jaw-bones.

The Lower Jaw-bone consists of two pieces united at an acute angle. The horizontal branch is very long, and its front end hollowed into a long socket, which is continued back to the first molar tooth-socket. The vertical branch is very long from before backwards, and thin; the coronoid process is slender and tall; the condyle is flat and oval; the angular process stretches inwards, forming a wide rounded surface behind, and a large concavity between itself and the horizontal branch.

(**.) The Fruit-eaters include the *Phalangers*, *Phalangista*, and the *Petaurists*, *Petaurus*, which, in reference to their head, are nearly approached to the *Kanguroos*.

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The Occipital bone has its basilar part wide and nearly square; the occipital hole is large and somewhat triangular; the condyles are narrow; the paramastoid processes descend below the base, are distant from the condyles, especially in the *Petaurists*, in which they are very large; the occipital surface of the bone is square, not extending outwards but a little beyond the top of each condyle, and low, being bounded above by the middle transverse part of the slightly developed occipital crest, in front of which projects the square coronal part between the hind ends of the parietal bones.

The Sphenoid bone has its body narrow in the *Phalangers* but wide in the *Petaurists*, and its external pterygoid processes are scarcely developed; but the internal, which are distinct, incline much outwards; its temporal plates are very large, and the back of the spinous processes expand each into a shallow concavity, which forms the bottom of the ear-drum, and is continued beneath the mastoid portion of the temporal to the paramastoid process of the occipital bone.

The Parietal bones are a pair, and swell outwards above and before the ears; their hind ends assist in forming the occipital crest, largely in the *Petaurist* but less in the *Phalangers*, in which also the slightly developed temporal crests arise at a point and diverge forwards into the upper front angles of the bone, which are lengthened to receive the hind end of the frontal between them; but in the former animal these crests are more developed, are nearly straight, and commence at once from the occipital crest.

The Temporal bones have their squamous and mastoid portions united into one; in the *Petaurist* the scaly plate is very large, but smaller in the *Phalanger*; the mastoid portion is very largely developed, and forms a considerable part of the occipital surface of the skull, resting on the top of the root of the paramastoid process, and forming in the base of the skull a broad flat thin face behind the auditory passage; it is largely filled with air-cells, and completely excludes the petrous portion from the exterior of the skull. The glenoid process stands well out, and forms a wide but shallow temporal pulley; its articular surface is flat, with a hind lip, on the inner side of which a little concavity perfects the front of the drum above the drum process of the sphenoid bone; the zygomatic process is short, sharp above, broader below, and the upper part of its root continues as a broad projecting ledge over the auditory hole to the mastoid portion, and like it is full of cells: the lower part of the auditory canal is a distinct spout-like piece.

The Frontal bones are longer in the *Petaurist* than in the *Phalanger*, and in the former the continued temporal ridges are more distinct, and run into distinct posterior angular processes, before which the short brow-ridge is very distinct; in the latter, however, neither are scarcely discernible; the temporal plates are contracted a little in front of their union with the parietal and temporal bones; the orbitar plates descend to those of the palate-bones.

The Ethmoid bone is rather lengthy, and has a large oblong partition-plate, rendering the Ploughshare bone if existing, very small.

The naso-orbitar plates form the principal part of each Palate-bone, joining above with the frontal, and externally with the upper jaw-bones; their palate-plates form a narrow bridge at the back of the palate, and a little process projects from their outer end within the hinder tooth-sockets of the jaw-bones, forming the back of the large gap which is perfect in front by

The palate-plates of the Upper Jaw-bones: the nasal plates are tall but nearly square, and from the bottom of their malar process a little stud, corresponding with that in the *Kangaroos*, though much smaller, is very distinct; the top of the hind tooth-sockets forming in the *Phalangers* a large bony floor to the orbits.

The Cheek-bones are thin, and have a posterior orbitar process most distinct in the *Petaurist*.

The Muzzle-bones have their palate-plates narrow in the *Petaurist*, but wide in the *Phalanger*, and in both the incisive holes are large slits; the nasal processes are lofty, and much cut out in front, so that the front ends of

The Nose-bones overhang them, especially in the *Petaurist*.

The Lachrymal bones form the inner upper part of the orbits, and their orbitar plate is very large.

The Lower Jaw consists of two stout pieces; the angular processes are little developed externally, and are rounded; the condyles are lengthy transversely, and nearly flat; and the thin coronoid processes in front rise considerably above them.

The *Koala*, *Phascolarctos* (Pl. V., fig. 34.), is placed by Owen in this Family, principally on account of the similarity in the form of its teeth; but it differs from them remarkably in the extreme shortness of the nasal plates of the upper jaw-bones; the large infra-orbitar pits produced by the extension of their malar processes, and the compression of the muzzle-bones, so that the Head seems to be almost all skull and jaws.

The Occipital bone has the great hole round, with small condyles situated on either side; the basilar part is wide and thin; the paramastoid processes (fig. 34. e. *) very lengthy and strong, and their front joining with the mastoid; the occipital surface is nearly square, and the crest overhanging.

The Sphenoid bone has its posterior piece united with the occipital by its widish body; the Turkish saddle has raised side edges; the temporal plates scarcely rise into the temporal pits; the spinous processes do not run into the articular sockets for the lower jaw, but between each and the corresponding external pterygoid plate there is an enormously large and long drum cavity (a.), which descends below the lower edge of the internal pterygoid plate. Of the two pterygoid plates the outer (b.) is low and square, but not separated by any pit from the internal (c.), which is a distinct bone of much larger size, and extending considerably behind and below it; the hinder order edge of the inner plate is rounded, and terminates in front in a little depending slightly hooked process (d.); the upper edge or base has the same T-headed form as in the *Ox*; its hinder branch runs along the inside of the drum cavity, and its front branch on the inside of the root of the nasal plate of the palate-bone.

The Ethmoid bone is probably large, if the space included by the frontal bone between the orbits be occupied by it; but its sieve-plate is small, and the holes in it very minute.

The Parietal bone is single; its temporal crests, distinct behind, soon run into one in front, and its front lower angles descend deeply to join the temporal plates of the sphenoid bone.

The Temporal bone has its squamous and mastoido-petrosal portions perfecting the back of the skull and the occipital crest. The scaly plate is long, but does not

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reach the frontal bone; the glenoid process is short, and the temporal pulley narrow; the articular surface deeply concave, and facing downwards with its hind lip much lengthened; thence the squamous plate arches backwards, and descends on the mastoid process: the deep zygomatic process projects directly forwards or at right angle with the glenoid process. The external auditory tube is deeply lodged between the lip of the articular surface and the mastoid process; the drum cavity is very large and nipple-shaped; it descends below the plane of the lower end of the pterygoid processes, and is so closely approached to the spinous process of the sphenoid bone that it is questionable whether it be not partially or wholly formed by it, but with the pterygoid process it has certainly nothing to do.

The Frontal bone is long; the temporal crests, diverging from the hinder part, run forwards and outwards, bulge over the orbits, and include between them the broad triangular frontal surface, the front edge of which joins the nose-bones and the nasal processes of the upper jaw-bones: the orbitar plates are joined to those of the lachrymal and upper jaw bones, and perhaps also of the ethmoid.

The Cheek-bones are very deep; their articular process descends round and against the outside of the articular surface on the temporal bone; the posterior orbitar process is distinct, rising up like a flat square stud, and forming with the zygomatic process, which is straight, and thus renders the temporal pit narrow, an angle into which the extremity of that process of the temporal bone is received; the orbitar edge descends, and its front bends suddenly at a right angle to join the upper jaw-bone.

The Palate-bones have each in their palate-plate a large square hole, and their united hinder edge is very deep.

The Upper Jaw-bones form with the roots of their hinder molar teeth, the inside of the bottom of the orbits; the malar process stands directly outwards from the side of the bone, and has in it a small infra-orbitar hole; the square nasal process ascends between the lachrymal and nose bone; it is very short from behind forwards, and is hollowed into a deep infra-orbitar pit.

The Lachrymal bones are triangular; their orbitar plate is large, but the nasal very narrow.

The Muzzle-bones are small and narrow as regards their palatine plate and both sockets, consequently the front of the upper jaw is very narrow; but their nasal plates are large, thin, and lofty, curving outwards and upwards; these, and the oblong Nose-bones being very wide, render the aperture of the nostrils of much greater breadth above than below.

The Lower jaw in this animal is remarkable for the length of its ascending branches equalling that of the horizontal; the base of the latter is sharp, a little curved, and before the front molar teeth truncated suddenly and obliquely upwards; their outer surface is rounded, and the inner flat, and the front supporting the small incisive teeth, short, slender, and compressed in correspondence with the muzzle-bones; the angular processes are not outspread horizontally, as in other Marsupial Beasts, but curve strongly upwards and backwards like the same processes in the *Rabbit*, of the same thickness as the ascending branch, upon the outside of which is a strong descending ridge. The condyles are not tall, their articular surfaces not very wide, but convex from behind forwards. The coronoid processes are thin, curve upwards and backwards, but do not overhang the condyles.

(***.) The Flesh-Eaters include the *Thylacines*, *Phascogales*, and *Dasyures*, of which the former bear a general resemblance to the Dog kind and other long-faced Predatories without pouches, and the latter to the Cat kind and others of the same Order with short faces.

The *Thylacine*, *Thylacinus*, has the Head large and long, with the orbits nearly in the middle of its length, the skull narrow and of small capacity, with deep occipital and temporal crests, wide temporal pits, and large jaws.

The basilar part of the Occipital bone is short and very wide; the great hole, not very capacious, is nearly oval, but rather angular above; the large condyles, about two-thirds of its height, project back beyond its plane, which, as well as that of the occipital surface of the bone, is vertical to the basilar part; the paramastoid processes are compressed, face forwards and outwards, and are of good length. The occipital surface, tall and concave, with nearly straight side-edges, is bounded above by the slightly overhanging crest, and not always united with the articular pieces of the bone, probably only, however, from want of age. From the front of the angle of the crest projects the commencement of the single temporal crest about half an inch long, and on each side of it the occipital drops, and is partially overlapped by the parietal bones protruding beneath them as a pair of triangular wedges, between which is a deep cavity for lodging the upper vermiform process of the cerebellum. In the *Ursine Dasyure*, *Dasyurus Ursinus*, the principal differences from the *Thylacine* are the regularly oval form of the occipital hole, the scarcely developed paramastoid processes, and the diminished height of the occipital surface. In the specimen examined, the articular pieces were still ununited above the occipital, both from each other and from the superior piece.

The Sphenoid bone consists of an occipital portion, a pair of internal pterygoid plates separate from, and an ethmoidal portion consolidated with, the ethmoid bone. In the *Thylacine* the occipital sphenoid portion is very lengthy from behind forwards, and its body wide; the Turkish saddle wide, convex transversely, with a triangular elevation in front, separating the lower edges of the optic holes, and underlapping the ethmoido-sphenoid piece, and having slightly raised sharp edges; the spinous processes not lengthy, but reaching the inner ends of the articular surfaces for the lower jaw, without assisting in their formation. Between them and the hind corners of the body rise, on each side backwards and upwards, an oval concavity, longest vertically, its inner edge bounded by a deep lip, and from its under part stretches backwards and downwards the deep thin cup of the front of the drum cavity, a vesicle which, with care, may be separated so as to render it doubtful whether it belongs to the sphenoid or temporal bone, with the squamous and petrous portions of which it joins behind and above, receiving in the gap of its upper outer edge, and the glenoid cavity, the spout-like external auditory tube; and having from its fore part a little stud joining the back of the outer pterygoid plate. The temporal plates, neither wide nor high, incline forwards and inwards, and again stretch outwards to underlap the frontal bone. The outer pterygoid plates are thin, and projecting in front, but behind each expands into a groove with edges, of which the outer is deepest, and sends a delicate spine backwards to the drum cavity. The inner



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pterygoid processes are distinct, considerably deeper than the outer, and have their upper edge lengthened much backwards to join with a little triangular flat process which descends from the edge of the body. The ethmoido-sphenoid portion has its body part thick to join the front of the occipital portion, but its olive process stretching backwards beyond, and overlapping it, is of square shape, has no transverse spines, and its edges underlap instead of rising within the frontal bone, but perfect the upper part of the optic holes. In the *Ursine Dasyure* the body of the occipito-sphenoidal portion is of nearly equal breadth throughout; its temporal plates, of a squarish form, rise up nearly vertically between the frontal and the squamous portion of the temporal bones; its spinous processes, much developed, stretch outwards and form the inner end of the articular surface for the lower jaw, between which and the body of the bone the back of the spinous process swells down into a large thin bony vesicle, forming the fore and under part of the drum, which extends back to the petrous portion, and has stretching from its front a thin ridge, continued to the outside of the outer pterygoid plate. The pterygoid plates are very shallow, but deepest in front, where the outer plate joins the hind end of the palate-plate of the upper jaw-bone; the inner plate is separate, of lengthened triangular shape, with its base joining to the palate-bone, of which the extremity is received between the two plates, and its apex gradually subsiding behind.

The Ethmoid bone in the *Thylacine* is of very considerable size, length, and depth, and diamond-shaped; the cells, very numerous and large, are enclosed on the top and sides by the frontal bone, but the hind half of their under surface is underspread by a thin plate of the bone itself, and only in front of this do the cells communicate with the nose; a deep longitudinal partition-plate separates them into two sets.

The Parietal bones are a pair; in the *Thylacine* they are short, but their inner connected edges curving upwards form the middle of the sharp single temporal crest; externally they curve quickly downwards, so that the cavity of the Skull is narrow, and their lower edges are large, overlapped by the squamous plates of the temporal bones; the back and middle part of their under surface perfects the pit for the cerebellar vermiform process, and in front of these, on each side, a distinct but not deep edge indicates an incipient bony tentorium. In the *Dasyure* the Parietal bones are longer, but their temporal crest is less tall; their front cleft to receive the frontal bones, between which and the temporal bones their lower front angles descend to the square-tipped temporal plates of the sphenoid bone.

The Temporal bones in the *Dasyure* have their squamous and mastoid portions forming a single piece, and the hinder edge of the latter, together with the outer edge of the petrous portion, perfecting the lower end of the occipital crest; the labyrinthic part of the petrous portion is very small, but a tall triangular plate rises up on its outer edge, partly resting against the front of the paramastoid process and vertical edge of the occipital bone, and partly appearing on the back of the small occiput, between the occipital bone and the squamo-mastoidal part of the temporal bone. The squamous plate, itself not large, has only a small portion forming the inner wall of the Skull, its margin largely overlapping the parietal and sphenoid bone; the mastoid process, compressed and well-marked, though small, forms the back of the external orifice of the auditory passage. The glenoid process stands not from the side of the squamous portion like a long triangular prism, its sharp edge above, its front face concave, forming the temporal pulley, its hind face convex, forming the front of the external auditory opening, and its lower edge descending considerably, so as to form a deep hind lip to the large articular cavity, concave from behind forwards, flat and wide transversely. The zygomatic process, curving outwards and forwards, at its commencement very deep, with its sharp upper edge inclined inwards, and the whole length of its broad under edge resting on the cheek-bone, but much shallower in front. The under part of the external auditory passage is a distinct spout-like piece, wedged in between the petrous portion and the drum cavity of the sphenoid bone. In the *Ursine Dasyure* a larger but shorter piece of the petrous portion appears on the back of the Skull, and its under surface forms a thin drum vesicle, somewhat in shape like a barley husk, with its long axis transverse, and immediately behind the drum cavity of the sphenoid bone. Its squamous plate is larger, but the glenoid process shorter and much overhung by the very deep zygomatic process, of which the upper edge inclines much inwards: the articular cavity is less wide laterally, and less deep.



The Frontal bones in the *Thylacine* are of considerable size and length; they form about half the upper part of the vault of the Skull, which however is scarcely a fourth of their whole length; the extent of the cavity of the skull is indicated externally by the contraction of the bones in the middle of the temporal pits, whence they again spread out to the back of the orbits, and the temporal plates being rounded from above downwards, are of an hour-glass shape, of which the front cone is considerably largest. The sharp temporal crest continues forwards, becoming gradually shallower, nearly to the front of the pits, then splits into two slight ridges, which, stretching outwards, become less distinct as they now run each into the corresponding blunt hinder angular process, from whence is continued forwards the distinct but not much developed brow-margins, which do not, however, terminate in any front angular process, they being deficient. The frontal surface between the ridges is slightly arched transversely, and below them descend the orbitar plates, of which the inner vertical part is the largest, but the upper back part narrow and long, forming a blunt angular edge with each temporal plate. The large space in front of the contracted part of the bone is principally filled by the ethmoid, but numerous large cells in the Frontal bone itself contribute to its large size. The hind and under edges of the temporal plates are received within the squamous plates of the temporal and the temporal plates of the occipito-sphenoid bones: the contracted part rests on the edges of the olive process of the ethmoido-sphenoid; the edges of the orbitar plates join with those of the palate and lachrymal bones, the back edge of both bones joins the parietal, and their front is overlapped by the hind ends of the nose-bones and the tops of the nasal processes of the upper jaw-bones. In the *Ursine Dasyure* the Frontal bones are comparatively short, but they are also contracted in their temporal plates; they are rounded transversely and suddenly towards the short brow-ridge, of which the larger part is formed by the strongly developed pointed

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hinder angular process, so as to define the upper edge of the orbit very decidedly.

The Cheek-bones in the *Thylacine* are very lengthy, concave beneath, with a shallow groove just above the edge: the hind end of the shallow zygomatic process perfects the socket for the lower jaw; its upper edge underlaps the corresponding process of the temporal bone; the posterior orbitar process, though short, is distinct; in front of it the bone deepens considerably as its extremity inclines inwards to join the upper jaw-bone, and form by its upper concavity the outer lower half of the orbitar margin, the plane of which faces obliquely upwards and forwards. In the *Ursine Dasyure* the bone is short, it also bounds the outside of the articular cavity of the temporal bone; its posterior orbitar process is sharp and distinct, and the whole length of the lower edge of its deep orbitar part rests on the upper jaw-bone.

The nasal plates of the Palate-bones in the *Thylacine* are very long and rather deep; their upper edge joins the frontal and lachrymal bones; their palate-plates immediately behind the last molar teeth form merely a narrow bridge, which bounds the back of a large aperture perfected in front by the upper jaw-bones, and in which is an attempt at division into two by a little projection from the front and back edge of the bones composing it. In the *Ursine Dasyure* this hole is irregularly triangular with the base behind.

In both animals the Lachrymal bones are very large, especially their orbitar plate: and the ridge separating it from the nasal plate, and perfecting the fore part of the orbitar edge, is in the *Thylacine* straight, with a slight curve outwards at bottom; but in the *Dasyure* it curves regularly throughout, and in both overlaps the front of the cheek-bone.

The Upper Jaw-bones in the *Thylacine* are very lengthy; their nasal plate lofty, slightly convex from above downwards, and hollowed near its middle; the tooth-sockets are wide behind but narrow in front, except at the very end, in which is the large socket for the cuspid tooth; the roots of the under molar tooth-sockets spread a triangular plate, forming the bottom of the front of the orbit, and on its outside the malar process, in the root of which is a large infra-orbitar hole, joins by a jagged surface to the cheek-bone; its front upper edge curves suddenly down to correspond with the concave lower edge of the muzzle-bone; the palate-plates are narrow, and their inner joining edges deep and forming above a deep thin nasal crest. In the *Ursine Dasyure* the nasal plate is shorter and convex, and the palate-plate wider.

The Muzzle-bones in the *Thylacine* have long nasal plates, rising upwards and inwards, with their hind edge concave and the front convex; their palate-plates are very narrow, and a lengthy slip runs along the floor of the nose on the side of the nasal crest of the last bone, the incisive hole is long and narrow; the front of the bone has small tooth-sockets, and the bottom of the nasal process a large shallow depression for the crown of the lower cuspid tooth. In the *Dasyure* these bones are shorter; their nasal plate has its front edge nearly vertical, and the incisive holes are tolerably large.

The Turbinated bones in the *Thylacine* are lengthy, and consist of numerous very delicate convolutions.

The Lower Jaw in this animal consists of a pair of lengthy branches, not very widely separate behind, and uniting at an acute angle in front; the base is rather convex, and rises suddenly in front; the angular process has the usual lateral outspread; the ascending plate is of considerable length, curving upwards and backwards into the compressed coronoid process; the condyle has its root sweeping upwards, and terminates in a wide articular surface, which is convex from behind forwards further back than the coronoid process, and external to it. In the *Dasyure* the jaw is stouter and its ascending branch more vertical.



(****.) The Insect-eaters consist of *Myrmecobii*, the *Bandicoots*, *Perameles*, and the *Opossum*, *Didelphas*; the two former kinds, in the lengthiness of their face and slenderness of their jaws, recall the Insect-eating Beasts without pouches; but although the latter has many resemblances to them, yet the enormous temporal crest with which their skull is furnished indicates their feeding upon much tougher food than insects, and which is known to be so.

In *Myrmecobius* the Skull is broad, and the upper angle of the Occipital projects between the hinder ends of the Parietal bones, of which the front edge is square.

The squamous plates of the Temporal bones are square, as in the *Rabbit*; the glenoid processes curve well outwards and forwards, and the articular surface on their under side is lengthy and concave, in the same direction, and from side to side lozenge-shaped, and the front perfected by the cheek-bone. Their zygomatic processes are short and straight: the drum cavity has similar shape to that of the *Cat*, but is principally formed by the sphenoid bone.

The temporal angle of each side of the Frontal bone joins at a point with those of the parietal, temporal, and sphenoid bones; its brow-ridges project outwards from the frontal surface with contracted bases like those of the *Camel* and *Rabbit*.

The large Lachrymal bones form the anterior third of the orbit, and, being interposed between the cheek and frontal, entirely exclude the upper jaw-bone from it.

The nasal plate of the long upper Jaw-bone is of low triangular shape; the hind tooth-sockets stretching outwards to the root of the malar process, as in the *Ornithorhynque*, form the floor of the orbit.

The hinder edge of the palate-plates of the Palate-bones have a transverse trigonal shape, and the gaps in them, which are perfected by the corresponding plates of the upper jaw-bones, are fitted up with plates of bone.

In the *Bandicoots*, *Perameles* (Pl. V., fig. 35.), the general lengthy form of the head, and more especially of the face, bears a strong resemblance to the Insect-eating Predatories. The drum cavities (a.) belonging to their Sphenoid bone behind, and within the spinous processes, which assist in forming the articular surfaces for the lower jaw, are very large, and pyriform horizontally. Behind them a similar but much smaller one (b.) on each side marks externally the position of the petrous portions of the Temporal bones; the tympanal rings are also present and distinct. In the *Hare-eared Bandicoot*, the gap (c.) in the palate, which is of very considerable size, and exposing the under surface of the Ethmoid bone, belongs entirely to the palate-plates of the Upper Jaw-bone, and is bounded posteriorly by a pair of little plates, each having a small hole in it, and joining the corresponding plates of the Palate-bones, which also have each a small hole. In the *Long-nosed Bandicoot*, the palatine hole is smaller, and the holes in the Palate-bones are deficient. The swellings on the petrous portions of the Temporal bones are also less distinct.

In the *Opossums* (Pl. V., fig. 32.), the Occipital bone



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(A.) has a massive nearly square basilar process, wider than its length, and with a mesial low keel; its great hole oblong square, with its greatest extent transverse, and with the broad condyles, which are convex vertically and face backwards, projects backwards on each side, and renders the occipital surface concave vertical up to the transverse ridge, which is much developed and overhangs it considerably; the paramastoid processes are large, compressed laterally, and between their roots and the lower ends of the crest is a slight gap on each side for the petrous portions of the temporal bones. Before the occipital crest is an angular projection, arched transversely, which thrusts in between the parietal bones and the deep parietal crest ($\phi$), commencing from the middle of the crest, runs forward to the front angle of the bone. The edges of the angular part are indented for junction with the parietal bones, but its outer corners are overlapped by those bones.

The Sphenoid bone (B.) is divided into two parts; the occipital portion is very large, and forms the principal part of the bone; its body, very long, thick, and wide behind, narrows as it proceeds forwards; its temporal plates are tall, thick, jagged, and indented behind, where overlapped by the lower edge of the squamous parts of the temporal bones, but thin in front and facing forwards and outwards at their junction with the parietal bones, and directly outwards where they join the frontal bone, and form a squarish pit for the ethmoido-sphenoid body, which is square, closely united with the back of the ethmoid bone, and has on each side of its fore part the small orbitar plate. The spinous processes stretch directly outwards, and are grooved behind, where joining the glenoid processes of the temporal bones, and assisting to form the articular surface for the lower jaw. Between the body of the sphenoid and each of its spines is a deep concavity facing backwards, to form the front of the ear-drum. The pterygoid processes are single, long, thin, and flat, continued horizontally forwards, and resting on the long pterygoid processes of the palate-bones. The Turkish saddle is a deep pit with raised side edges in the upper surface of the body; and before it a pair of grooves separated by a mesial ridge, lead to the optic holes, which partially belong to each piece of the Sphenoid bone.

The Ethmoid bone is very long, narrow behind, but widening considerably in front, and consisting of numerous lengthy convolutions, separated into two sets by a large oblong square nasal process.

The Parietal bones (C.) are nearly square, convex from above downwards and outwards, and from behind forwards, except the lengthened thin blunt point which overlaps the occipital behind, and a similar one which overlaps the frontal bone before, the two bones diverging in front at an angle, and behind separated by a square gap. At the junction of the inner upper edges of the bones, the deep thin parietal ridge rises, which is thickened and jagged on its ridge. The hinder and larger part of the lower edge of each bone is overlapped by the squamous part of the temporal bone, and the thin front part rests on the temporal plate of the sphenoid bone.

The Temporal bones (O.) consist each of a squamo-mastoidal and a petrous portion, but whether it has a bony tympanal piece and auditory passage is doubtful. The squamous plate, rounded, is almost completely shut out from the skull cavity by the sphenoid and parietal bones, and by the petrous portion, against the outside of all which it laps. The trigonal glenoid process stands out, and has beneath the articular surface for the jaw, with its greatest extent transverse, its concavity from before backwards, and its hind edge guarded by a deep lip, which also forms the front of the auditory passage. The zygomatic process is very deep, and then wide below, as it rests by its whole length on the cheek-bone, but sharp on its upper edge, which sends back from its root a rounded edge over the top of the auditory passage to the little-developed mastoid process, which perfects the lower end of the occipital crest. The petrous portion appears on the back of the Skull in the cleft of the occipital bone, and also below in the base.

The Frontal bone (E.) is of considerable size and great length. The parietal crest, continued forwards from the middle of its hinder edge, soon bifurcates, and each branch curves outwards and forwards to terminate in the well-marked though small posterior angular processes; behind these curve vertically downwards the temporal plates, which are also concave outwards, and bounded in front by an indistinct oblique ridge from each angular process, separating them from the nearly flat vertical orbitar plates, by which the lower edges are lapped against by the orbitar plates of the palate-bones, and the front by those of the lachrymal, so that the ethmoid bone is entirely excluded from the orbits. The upper frontal surface, nearly flat, is deeply cleft in front for the nose-bones, by which the lengthened parts are almost completely overlapped. The bone does not exhibit any cells.

The Cheek-bones (H.), very large and deep, convex and thin above, very concave and thick beneath, curve forwards and inwards, forming the principal part of the zygomatic arches; a large portion of the upper edge is cut away, on which the zygomatic process of the temporal bone rests, without deepening the arch; and the hind end is lengthened inwards below, and hollowed to complete the front of the jaw-socket thus formed by the temporal, Cheek, and sphenoid bones. The front end, partially scaly and partially indented, rests on the upper jaw-bone.

The Palate-bones (M.) have their palate-plates received within the hinder ends of those of the upper jaw-bones, and when appearing in the palate have a lengthened hexagonal form, with the hinder and towards the throat turned down like a lip; but a large part of each plate is underlapped and concealed by the corresponding plate of the jaw-bone, and forms a spacious triangular floor to the orbit. The orbitar plate is thin but not large; its junctions have been already mentioned. The pterygoid processes run back long, thin, and pointed, beneath those of the sphenoid bone; they are also remarkable for being lengthened horizontally inwards in front, each forming a ledge upon which rests the corresponding lower edge of the ethmoid bone, and as they are not much above the palate-plates, the posterior orifices of the nostrils are low but wider; each plate has an irregular hole near its hinder edge, and a long slit in front.

The Upper Jaw-bones (J.) are long, and have very wide lengthy triangular palate-plates, wide behind and narrowing in front; their hind edge is oblique to form the gap for the palate-bones, and each has here a cleft, which, with those in the former bones, form long narrow holes, and a small cleft in front of each belongs to the incisive holes. The outer margin is widened by the tooth-sockets, which behind are exceedingly broad. The

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Zoology. nasal plate curves upwards and inwards; its hinder edge is concave for the lachrymal bone, its upper edge wavy for the nose-bone, which it overlaps, and its front oblique, and also overlapping the hind edge of the muzzle-bone. The malar process is large, but does project much outwards or backwards.

The Lachrymal bones form the fore and inner margin of the orbits, and have very large orbitar plates.

The Nose-bones (L.) are very long, broad behind, and together forming a projecting roof, which runs into the nasal gap of the frontal bone.

The Turbinated bones are long and very complicated. The Ploughshare bone is very long, but rests only on the front of the junction of the palate-plates of the upper jaw-bones.

The nasal plates of the Muzzle-bones are tall and narrow, incline inwards as they rise up on the front of the upper jaw-bones, and support the front of the nose-bones; their tooth-sockets, not very thick, curve forwards and inwards, till the two bones meet and form the muzzle. The palate-plate is short on the outside of the incisive cleft, and long within where joining its fellow; but a thin, delicate, spear-shaped piece runs above the palate-plate of the upper jaw-bone on the floor of the Nose.

The Lower Jaw of the *Opossums* consists of a pair of strong pieces, of which the base is much rounded downwards, and thick; but the tooth-sockets are not wide or capacious, though many in number. The condyles are placed on the top of the upward curved wide angular processes, are tolerably wide and convex upwards; the coronoid processes are immediately in front of them, thin, tall, and curving backwards, as in Predatory Beasts.

The *Wombat*, *Phascolomys*, has some remarkable peculiarities.

The Occipital bone has its great hole large; the condyles are very small, and nearly on the same plane as its lower edge; the basilar process is wide, and very thin; the paramastoid processes very small; the occipital surface is nearly square, vertical, and low; the occipital crest is sharp, curves backwards, and perfected on each side by the parietal bone.

The two portions of the Sphenoid bone remain ununited; the Turkish saddle has its sides elevated; the temporal plates rise up in angular form between the squamous plate of the temporal and the temporal plate of the frontal to the angle of the parietal bone, and all four meet in a point. There is not any pit between the pterygoid plates, but there is one on the outside of each external plate, and the internal plates are distinct bones, without any hoop-like process.

The Ethmoid bone has but a small cock's-comb, and is well received into the frontal bone; its nasal plate is very long.

The Parietal is single: its coronal surface is flat, with the lateral edges bent downwards, forming the straight temporal crests, and overlapped by the scaly plates of the temporal bones; the front upper angle of each parietal bone furking forwards receive between them the frontal part of the frontal bone, and are interposed between it and the orbitar plates.

The squamous and mastoid portions of the Temporal bones assist in forming the angles of the low triangular occipital surface of the Skull. The squamous plate is large, and stretches far forwards; the glenoid process, curving much outwards and forwards, has the temporal pulley very spacious, and the articular surface concaved downwards transversely, very narrow from behind forwards, but widening externally, and becoming a little convex as it is deepened by the cheek-bone; its inner end is bounded by a strong descending process behind, and within which is the swelling tympanal cavity formed entirely in the temporal bone, and excluding the petrous part of the bone from the exterior of the Skull. The external auditory passage is a distinct piece, lodged in a deep cavity formed by the glenoid and mastoid processes, the latter of which is much developed, and stands out.

The Frontal bone is single, large, flat, and squarish, broadest in front, and having slight indications of brow-ridges and angular processes; the lower nearly straight edge of its orbitar plate rests on the palate, upper jaw, and lachrymal bones.

The Lachrymal bones are of triangular shape, their base very long, and a knob interposed between the orbitar and nasal plates, of which the former is the longest.

The Cheek-bones have their zygomatic part straight and trigonal; the orbitar portion is very large, the internal orbitar process large, and the lower margin of the orbit concave, and projecting forwards between the lachrymal bone and the nasal process of the upper jaw-bone, recalls the form of the orbit in the *Dugong*.

The Upper Jaw-bones each contain a large cell; their tooth-sockets are very deep, and ascend on the inside of each orbit and into the temporal pits; in front, the malar process is concave, but jutting behind. The nasal process, thin and narrow, rises between the cheek and muzzle bones to the nasal and frontal bones; its infra-orbitar hole is small.

Each Palate-bone has, in its palate-plate, a very large triangular hole, so that the two bones together have a T-shaped form, the stem of the latter separating the apertures.

The Ploughshare bone is very thin and slender, and rests on both palate and upper jaw bones.

The Muzzle-bones have their palate-plates large and very thick for the large incisive teeth, but seperated from each other by a deep groove; their Incisive holes are narrow; their nasal plates rise upwards, curve inwards, and give great breadth to the nostrils.

The Nose-bones together form a large triangle, with the base resting against the frontal, and its sides between the upper jaw and muzzle bones.

The Lower Jaw-bone is very massive, and its two pieces are connected by more than one-third of the total length of the bone; the angular processes, much outspread and flattened, have the ascending branches springing up from their middle with a deep cavity on either side; the very wide and convex condyles are thin, but widened on their outer, and hooked downwards on their inner end; the coronoid processes are vertical and very slender.

(H.) The Pachyderms or Thick-skins, according to Cuvier's arrangement, include three families, viz.:—the Trunked, Common, and Single Hoofed; but the latter of these, having no resemblance either in the construction of the head or limbs, nor any similarity in habits, must, as has been already done by Illiger, be formed into a distinct Order. Thus restricted, the general character in the Heads of the Thick-skinned Beasts is the large development of air-cells between the tables of the skull-bones generally, and sometimes also in the face-bones, all of which communicate with the general cavity of the nostrils. By their production at one or

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other part of the skull or face, very peculiar and characteristic external form is produced. But it must be recollected that the bulkiness of the skull in this Order is no indication of the correspondent capacity, or of the size of the brain, but the contrary; for almost in every instance their brain is extremely small, both in reference to the largeness of the skull and the general bulk of the animal. It is also further to be observed, that the cells do not exist in the young animals, but are gradually developed as they advance in age, though not equally through the whole walls of the skull; at the base the cells are few, and in the temporal pits immediately behind the orbits not very deep; but they are very large and deep at the back, and over the vault of the skull from ear to ear, thus widening the skull enormously in this region, and by its lateral extension producing the great depth of the temporal pits.

(*.) The Trunked Family consists of the *Elephants* only; to these, however, Cuvier has added the fossil *Mastodons*, which in size and general arrangement are so closely allied that they must form part of the same group. The most striking characters of the Head in this Family, are, the great height and width of the skull above the ears, and the great width from within outwards of the temporal pits; the wide gaping aperture of the nostrils, high up on the face between the orbits, with its small nose-bones, and with the large portion of its margin formed by the muzzle-bones, recalling very decidedly the aperture of the blow-holes in the Spouting Cetaceans; the verticality and large size of the muzzle-bones, in accordance with the bulkiness of the roots of the large tusks or cuspid teeth which they sustain; and the large size of both upper and lower jaw, with their capacious tooth-sockets for lodging the enormous grinders.

The Occipital bone (A.) very early unites into one with the occipito-sphenoid long before the junction of its own several pieces. The basilar process is short, wide, thin, and concave transversely above; the vertebral hole is round, and the condyles resemble quarter sections of a solid sphere, with the long diameter nearly vertical, and the convexity facing outwards and backwards; the paramastoid processes are mere little elevations. The occipital part of the bone is very lofty, and its angular upper extremity bent forward to project between the hind edges of the parietal bones, and with them form the very summit of the skull; the transverse ridge is distinct and rounded; the vertical ridge short, but deep and thin, with a deep depression on each side depending on the great development backward and outwardly of the air-cells between the tables of the skull, which produce two very large protuberances behind.

The Sphenoid bone (B.) is divided into two pieces, of which the occipito-sphenoid has the body wide, but its Turkish saddle is not very well marked; the spinous processes are small and short. The pterygoid processes (B. **) are remarkable for the confluence of their two plates (B. B.), so that on each side from the under part of the bone descends a large and long process, concave from above downwards and from within outwards, with its hollow facing forwards, in which is lodged the corresponding tuberosity, or hind-tooth socket of the upper jaw-bone, and its lower edge resting on the palate-bone: a very small portion of the root of the outer margin of this concavity enters the temporal pit, and is the only representative of the temporal plate. In the ethmoido-sphenoid bone, the transverse spines are deep and square, and the outer under angle of each sends into the orbit in the angular gap at the bottom of the orbitar plate of the frontal bone a pointed process, on the inner side of which is the optic, and on the outer side the common lacerated orbitar and round hole.



The Ethmoid bone (F.) is wide and heart-shaped; its sieve-plate is divided into two concavities by the well-developed broad cock's-comb, of greater breadth above than below. The convolutions, divided into two sets by the stout partition-plate, are little complicated and short; part have their lower ends free in the nostrils, but those near the outer edge of the bone rest against thin plates which cut off their direct communication with the nose.

In the Temporal bone (D.) the squamous and mastoid piece, united very early, form one, as the petrous and tympanal, also united, form another piece. The petrous portion is little seen externally; but the drum walls assume a triangular shape, descend, and have a lengthened flattened point curving forwards behind the pterygoid process of the sphenoid bone. The squamo-mastoid portion has its two tables widely separated by air-cells, specially above the small external auditory aperture, upon which depends the great width of the Skull at this part. In front of the auditory hole, the squamous plate inclines suddenly inwards, almost at right angle with the side of the Skull above the ear. The zygomatic process (ζ.) is short, straight, and directed forwards; from its root runs inwards in front of and below the whole length of the external auditory passage, the glenoid process, convex from before backwards, and slightly concave laterally.

The Parietal bones (C.), arched from behind forwards, but nearly flat transversely, have their hind edges divergent to receive the occipital bone, and their front angles also divergent to enclose the back of the frontal bones. On each side the well-defined but rounded temporal crest sweeps from before backwards, outwards, and downwards to the temporal bones; and below the crests the bone descends vertically to join the ethmoido-sphenoid and the frontal bones, and form the principal part of the temporal pit. Each bone immediately above the swelling part of the temporal bone swells out also considerably; and upon this outspreading of these two pairs of bones depends the great width of the back of the skull and the lateral width of the temporal pits; the anterior upper angle is much lengthened, and laps over a large part of the temporal plate of the frontal, excluding it from the pit.

The frontal portion of the Frontal bones (E.) is a wide band, in shape like a half hexagon, the three hind edges of which are received within the lengthened anterior angles of the parietal bones. Each lower end of the band terminates in the short rounded brow-ridge, with its anterior and posterior angular processes, of which the latter is best defined, and from it passes back to the hind edge of the bone a thin sharp ridge, above which is the temporal and below it the orbitar plate, facing directly outwards, and by its lower margin joining the upper jaw and lachrymal bones, the latter of which is thin, long, and like a flattened tube laid horizontally. The large ethmoidal gap is vertical, with a little inclination downwards and backwards. The half hexagonal space produced in front by the divergence of the frontal bones, to form the margins of the orbits, includes the nasal and muzzle bones, with the intervening nasal aperture.

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The Cheek-bones (H.), not long, but nearly straight, stretch forwards and a little inwards; their hinder half, shallow and wide, underlaps the whole length of the zygomatic process of the temporal bone, and is indeed continued rather behind it, forming an external boundary to the articular surface of that bone; the front half is deep but thin, rises like a step above the hinder half to the level of the zygomatic process of the temporal, deepens as it is continued forward in part to butt against and in part to rest upon the malar process of the upper jaw-bone, and forms a very indistinct blunt orbitar process, far distant below the angular process of the frontal bone.

The principal part of each Upper Jaw-bone (J.) consists of a large and deep oblong chamber, lodging two or three molar teeth, of which the outer wall descends from the lower edge of the orbitar plate of the frontal, assisting to form the inner wall of the orbit; and the inner wall descends from beneath the sieve-plate of the ethmoid, forming the outer wall of the nostril; the upper and back edges of the plates connected by a bony bridge, and the hind end rounded, and received in the concave pterygoid process of the sphenoid bone. The fore and upper part projects outwards a pair of stout processes, which, soon coalescing, form the large infra-orbitar hole; and the single process thus formed, deep and moderately thick, bends backwards and outwards, as the malar process, to join with the cheek-bone. The root of the upper process rises sharp, and runs between the front angular process of the frontal and the nasal plate of the muzzle-bone, and on its outside is a lengthy gap in which lies the lachrymal bone, still farther out between which and the cheek-bone is the orbitar process of the Upper Jaw-bone, or floor of the orbit, not very extensive, of triangular form, with its front edge rounded down towards the face. The nasal plate continued downwards and forwards, from the lower root of the malar process, curves under like a scroll to join in a sharp edge the narrow palate-plate which splays outwards in front from its fellow, and, widening, forms a large and lengthy concavity in which rests nearly the whole length of the corresponding muzzle-bone.

The Lachrymal bones (O.) are like flattened tubes, inserted for some distance between the orbitar plate of the frontal and of the upper jaw-bone; its orbitar plate, in comparison with the size of the bone, is lengthy; its nasal plate small, and bounded externally by a little stud.

The Nose-bones (L.) are like a pair of hollow trigonal pyramids, with their base upwards and forwards, and their apex thrust into the frontal bones above the ethmoidal gap; the hind edge of the base is rounded, the inner straight at its junction with its fellow, and the front edge concave, the concavity on each bone appearing more marked by the lengthening of the inner anterior angle. The under face of the bones which form the roof of the nostril have each their outer edge cut out so as to form an aperture, perfected by the corresponding muzzle-bone, to the large cavity of which each bone contributes.

The Muzzle-bones (K.) form nearly all the front of the face below the aperture of the nostril; together they form a square space, along the centre of which descends a deep wide concavity, supporting the root of the animal's trunk; this increases in depth in proportion to the growth of the great tusks, the sockets for which are formed on the outer half of each bone, ascending up to the top of each vertical part, and become thicker and larger as the tooth-pulp and tooth increase in size; the upper end of each bone forms the bottom of the nasal aperture, and an upper branch curves outwards and upwards to join the nose-bone, and forms the side of the nostril.



The Palate-bones are thin; their vertical nasal process helps to form the back and outer part of the nasal apertures; their palate-plates are thrust in squares into the palate, and a little horizontal process runs between the last tooth-socket and the pterygoid process of the sphenoid.

The Ploughshare bone, thin and deep, stretches forward to the palate-plates of the upper jaw and muzzle bone; its base can scarcely be said to spread out on account of the narrowness of the hind and upper part of the nostrils; but it divides into a pair of vertical plates, which join the lower edge of the partition-plate of the ethmoid bone.

The Lower Jaw (O.) has short horizontal branches which contain very large molar tooth-sockets corresponding with those in the upper jaw-bones, the hindmost of which is remarkable as being engulfed within the root of the ascending branch, and being the nest in which they are formed, whence successively issue new molar teeth as those in front wear down, move forward, and fall out. The horizontal branches join in front at an angle, and obliquely from the upper edge to the base of the jaw; and in this junction an odd-shaped, narrow, spout-like groove (†.) is formed. The angular processes are rounded, as are also the hind edges of the ascending branches, of which the fronts are sharp and thin. The coronoid processes are low, but the condyles distinct from them and tall, with their articular surfaces wide and convex, both from behind forwards, and from side to side.

(**.) The Trunkless Family includes the various kinds of *Swine*, *Tapiirs* (Pl. V., fig. 38.), and *Rhinoceroses* (fig. 39. 49.); and at its very extreme, if not, indeed, as according to Illiger, forming a distinct family, the *Hippopotamus*, which possesses some very peculiar characters. The most remarkable general character is the existence of numerous air-cells between the tables of the Skull, specially on the upper and back part, where the occipital part of the occipital bone is very lofty and vertical; the frontal cells are also largely developed, and in the *Rhinoceroses* the nasal, and particularly the muzzle bones, which are of enormous size, and completely overhang the aperture of the nostrils; whilst, on the contrary, in the *Tapiirs* they are very short, have very little connexion with the Upper jaw-bones, between which the aperture of the nostrils is very long and gaping.

The Occipital bone (A.) in the *Swine*, *Babiroussa*, and *Rhinoceros* has its occipital surface lofty, and presenting three more or less triangular spaces. The middle one has its apex below, at the top of the vertebral hole, and its base above, formed by the transverse occipital ridge or crest, of which the angles project far backwards and produce a large transverse concavity. The whole hinder edge of this crest in the *Rhinoceros* also overhangs the back of the bone, and the front is lengthened and projecting between the hind edges of the parietal bone. Below the lateral edges of this middle triangle are the other two, more flat and slightly inclined outwards: from their outer under angles descend the paramastoid processes, of considerable size and length, longest in the *Swine* and shortest in the *Rhinoceros*. In

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the *Tapiir* the occipital surface of the bone is pentagonal, the base below and the apex above: the upper two edges and apex project so greatly backwards as to stand beyond the occipital surface, like the gable of a ridged roof, with an intervening deep triangular pit: its paramastoid processes are short and curved inwards.

Of the Sphenoid bone the occipito-sphenoid portion is anchylosed to the occipital bone; its body is short, flat, and narrow in the *Swine* and *Babiroussa*, but thick and rounded laterally beneath in the *Rhinoceros* and *Tapiir*: the spinous processes are short: the external pterygoid plates alone belonging to the bone, in the *Rhinoceros* and *Tapiir*, very stout, and scarcely forming any pit behind, but in front deeply grooved from the pterygoid holes; in the *Swine* and *Babiroussa*, by the junction in the former of a short and in the latter of a long independent internal pterygoid plate; with the inner edge of the wide external plate large posterior pits, as well as wide and deep anterior ones, are formed; the outside of the root of the pterygoid process rises up into the temporal pit as a temporal plate. In the orbits only a small orbitar portion of the ethmoido-sphenoid appears, in each of which are two holes.

The Parietal bones (c.) early unite into one, which forms a more or less wide crown to the Skull, as in the *Rhinoceros*, *Swine*, and *Babiroussa*, or a longitudinal crest, as in the *Tapiir*. These differences depend on the size of the temporal pits and their surrounding edges. In the *Tapiir* the temporal pits are bounded above by the longitudinal crest continued from the front angle of the occipital along the middle of the Parietal, which descends on each side like a slanting roof to join the squamous plate of the temporal. In the *Babiroussa* the temporal ridges curve outwards and downwards towards the posterior angular processes of the frontal bone, leaving a flat triangular space between them; in the *Swine* the temporal ridges are farther apart behind; consequently the crown of the Skull is broader and the temporal plates of the bone more vertical; in the *Rhinoceros* the crown is more oblong, square in shape, but the temporal ridges are scarcely discernible. The front angles of the bone are more or less lengthened so as to include more or less perfectly the back of the frontal bone or bones.

The squamous and mastoid portions of the Temporal bones (D.) form a single piece in each bone. The hind edge of the mastoid process is vertical, and joins the front of the root of the paramastoid process of the occipital: in the *Swine* and *Babiroussa* it is indistinct, but in the *Rhinoceros* (σ.) and *Tapiir* it is large, trigonal, and forms the hind boundary of the external auditory opening; the squamous plate is low, and runs forward to the frontal, separating the parietal from the sphenoid bone. The articular surface of the glenoid process is wide laterally and convex from behind forwards: the process itself in the *Swine* and *Babiroussa* is deep and slightly concave behind, and in it lies the bony external auditory passage running downwards and inwards to the drum; but in the *Tapiir* and *Rhinoceros* the process is not deep: the hinder lower edge bounds a transverse cavity behind the articular surface: in the *Tapiir* it becomes a broad concave process, and in the *Rhinoceros* a stout process, (τ.) longer than the mastoid, which in these animals forms the front of the auditory passage, and prevents the backward dislocation of the condyle. The zygomatic process in the *Swine* and *Babiroussa* is almost a rectangular triangle; and in consequence of the depth of the glenoid process its vertical hind edge is much longer than the base, and rises above the external auditory aperture; its front concave edge, as it approaches the cheek-bone, begins to rise up as a little pointed process within the posterior orbitar of that bone, and is continued forward, assisting to form the lower edge of the orbit, to the malar process of the upper jaw-bone. Upon the shortness of the base, which runs forwards at right angle with the articular surface, depends the small extent of the temporal pit; its lower edge is rounded and rests entirely on the concave zygomatic process of the cheek-bone in the *Swine*, but less entirely in the *Babiroussa*. The zygomatic process (ζ.) in the *Tapiir* and *Rhinoceros* is not deep but longer, curving gently forwards and outwards, is only partially underlapped by the cheek-bone, but reaches forward to the upper jaw-bone. Behind, on the inner side of the root of the glenoid process, descends the long irregular drum, entirely excluding the petrous portion from the exterior of the skull, and of which the cavity is very small in the *Swine* and *Babiroussa*. It is doubtful whether the *Tapiir* and *Rhinoceros* have any bony drum, their small petrous portion being generally seen externally projecting into the large lacerated basal hole, and there is not any floor to the auditory passage.

The Frontal bone (E.) in the *Swine* and *Babiroussa* has its upper surface flat, forming the widest part of the Skull between the posterior angular processes, which are well defined, receive the front ends of the temporal ridges of the parietal bone, and distinctly separate the temporal pits from the orbits; the brow-margins are also sharp, decided, very convex, and terminating before in the broad anterior angular processes. The hind angular edge runs back into the forked edge of the parietal bone; the front edge projects a pair of nasal processes, with a wide intermediate gap to receive the hind ends of the nose-bones, whilst their outer edge rests on the lachrymal and upper jaw-bone; the temporal plates are small, but the orbitar deep, though not wide. In the *Tapiir* the temporal plates descend on either side like a ridged roof, as in the parietal bones, the single longitudinal crest being continued a little upon the upper surface of the frontal, but it soon splits into the two ridges, which diverge from the triangular frontal surface and descend on either side to the little defined posterior angular process, and thence continue forwards as the very slightly arched brow-ridge to the anterior angular process which rests on the lachrymal; the brow-ridge, vertical and thin, does not but slightly overhang the orbitar plate, which is also nearly vertical, with a slight inclination inwards below to its junction with the sphenoid and palate-bones, and in front with the lachrymal, of which the orbitar plate is very large. The front edge of the frontal surface projects from its middle the angular nasal process, which is interposed between the roots of the nose-bones, received in angular gaps on each side of the process, the outer edges of which are separated by a deep groove running first between it and the brow-margin, and then forward between the latter and the nasal process of the upper jaw-bone. In the *Rhinoceros* the frontal surface is flat, oblong, and its hind semi-hexagonal edge received within the projecting points of the parietal; the front edge is straight, excepting a short, small, angular nasal process; the orbitar plate is separated by a slight oblique ridge from the temporal; it joins below with the sphenoid, with a small part of the ethmoid



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which appears in the orbit, and with the orbitar plates of the palate-bone.

The Lachrymal bones (O.) in the *Swine* have their facial surface short and square, but in the *Babiroussa* and *Tapiir*, long and narrow, and in the latter are a pair of projecting bony studs: in the two former the orbitar process is not large though it shuts the upper jaw-bone out of the orbit; but in the *Tapiir* it forms more than half of the inner wall of the orbit. In the *Rhinoceros* the orbitar plate is small and the nasal large, and the angle form between them has but a single stud.

The Cheek-bones (H.) are very deep in both *Swine* and *Babiroussa*, but especially in the former, in which they form the lower orbitar margin by their thick rounded edge, of which the hind extremity rises up as a well-marked pointed interior orbitar process, behind and below which a deep step gives rest to the zygomatic process of the temporal bone: the front end of the Cheek-bone bends a little inwards, and more or less broadly to overlap the malar process of the upper jaw-bone. Its upper front edge joins the under part of the lachrymal bone, on the height of which depends the greater vertical than horizontal extent of the orbitar aperture. In the *Tapiir* this bone is much longer; the extent of the lower orbitar margin greater and less concave; but it joins by the whole of its inner surface to the orbitar plate of the upper jaw-bone, which is confounded with its malar process, its greatest depth below the posterior orbitar process, which is less definite; its zygomatic process but little underlaps that of the temporal bone, and in the *Rhinoceros* it is much the same.

The Upper Jaw-bones (J.) are lengthy, and upon the depth of their nasal plates depends principally the depth of the upper jaw. In the *Swine* and *Babiroussa* this bone does not assist in the formation of the inner wall of the orbit; its malar process, deep and large, especially in the *Swine*, stretches outwards to its junction with the cheek-bone, having reached which it bends back, and sends along the inside of that bone a process joining the zygomatic of the temporal bone; at the back of the root of the malar process is the large hind aperture of the infra-orbitar canal, from between which and the last tooth-socket a flat pointed process rises up between the orbitar plate of the palatine and the pterygoid process of the sphenoid. The palatine processes are very long, and are wider at the tusk-sockets than at any other parts; they do not reach as far as the hindmost tooth-sockets, but the intervening square gap is filled by the palate-bones: a small gap between their front ends, which assist in forming the incisive holes, receive the palate-plates of the muzzle-bones, and their outer edges are received within the nasal plates of those bones. The tooth-sockets are very large behind, but do not stretch beneath the orbits; in front they gradually diminish to the enormous sockets (one in each bone) for the tusks or cuspid teeth: these in the *Swine* stand outwards with a large bur on their upper surface, and from them the tusks project out of the mouth at first on the plane of the palate; in the *Babiroussa*, however, the tusk-sockets rise upwards, and a little curved forwards on the outside of the nasal plates, and in shape resemble the flattened bowl of a tobacco pipe, the teeth therefore springing from them curve upwards and backwards exterior to the cheeks. In the *Tapiir* the Upper Jaw-bone is remarkable for the great extension backwards of its tooth-sockets, which pass along the bottom of the orbits half across the temporal pits, and with the lengthened malar process form a flat floor to each orbit. The nasal plate is generally low, and the greater anterior part of its upper edge unconnected with the nose-bone inclines inwards, and joins the front ends of the convolutions of the ethmoid; the hinder part of the plate is however produced into a long thin nasal process, which rises upwards and backwards between the inside of the orbitar plate of the frontal and the nose-bone on each side. In front of the molar tooth-sockets a large sharpish edge is continued to the front end in, which is a small socket for the little cuspid tooth. The palate-plates are vaulted, and a large angular gap between them in front forms the back of the incisive hole. In the several species of *Rhinoceros*, the flattened roof of the molar tooth-sockets assists in forming the floor of the orbits, in which the flattened upper surface of their malar process and the expanded upper orbitar margin of the cheek-bone participate, and the latter to a very considerable extent in *Burchell's Rhinoceros*. The nasal plate is low and short, but it is nearly as deep in front as behind, up to the aperture of the nostrils, when it suddenly drops to a shallow ridge, which with its fellow forms the floor of the nostrils into a shallow gutter: the seeming depth of the bone at this part depends on the continuance forwards of the toothless ridge in front of the tooth-sockets: in the *Two-horned* species this process is longest and most slender, in the *One-horned* deepest and thickest, and in *Burchell's* deep, but very short, its extremity deeply indented to receive the ends of the muzzle-bone.

The Muzzle-bones (K.) in the *Swine* and *Babiroussa* have their nasal plate deep and extending far back between the upper jaw and the nose-bones; its lower edge is thickened to form tooth-sockets. The palate-plate is short and slender, and forms with the plate of the upper jaw a small oval incisive hole. In the *Tapiir* (fig. 38.) the muzzle-bones become united into one; their nasal plates are much rounded above, stretch back some distance on the upper jaw-bones, and perfect the angular form of the floor of the nostrils. Their junction in front is very wide and rounded from above downwards, and from side to side; it lodges several incisive teeth. No palate-plates exist, and a small cleft below perfects the front of the single incisive hole. The Muzzle-bones in the *Two-horned Rhinoceros* (fig. 40. K.) are long and trigonal, with the tooth-socket opening in the base or under surface of each; the nasal plate behind slightly overlaps that of the upper jaw-bone; but in front it thins, joins its fellow by the inner face, and has its point inclined upwards. In the *One-horned* species (fig. 39. K.) the bone is more bulky and contains a tooth; its hinder end scarcely overlaps, and its front is full and rounded. In *Burchell's* animal (fig. 40. K.), the bones are still smaller, and scarcely project beyond the jaw-bone, and contain no tooth. No palatine process in either runs back to that of the upper jaw-bone, and therefore the incisive hole is single.

The Nose-bones (L.) in both *Swine* and *Babiroussa* are long and flat, rather arched at their hinder part, flat in front in the former, but in the latter the reverse; in both kinds the front extremities of the bones project nearly as far as the muzzle-bones, and are slightly curved downwards at their tip: their outer edge is connected with the whole upper edge of the nasal plate of the upper jaw-bone, and of the muzzle-bone as far forward as the root of the hindmost incisive tooth. In the *Tapiir* and *Rhinoceros* two remarkable and very contrary conditions



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of the nose-bones are presented. In the *Tapiir* (fig. 38. L.) these bones are short, consisting of two parts, the frontal portion or body of the bone, and its maxillary process; the frontal portions of the two bones, joined by their inner edges, together form a large projecting triangular plate with the apex in front, and the side edges quite free to the hind corners, which are rounded; and behind these each bone is lengthened to run into a corresponding angular gap in the frontal bone, but producing between themselves another angular gap in which the pointed nasal process of the frontal bone is received. The outside of this lengthened base descends to the inner hind end of the nasal process of the upper jaw-bone, and then projects upon it a process about an inch long, which bounds the anterior nasal aperture below, as the frontal portion does above. In consequence of this form of the Nose-bones, and the great shallowness of the nasal plates of the upper jaw-bones in front, the aperture of the nostrils is of very enormous size, entirely upon the upper surface of the face, and only partially covered behind and above by the Nose-bones, and in the open space the convolutions of the ethmoid bone are seen projecting and joining the inverted edges of the nasal plates of the upper jaw-bones. In the *Rhinoceros* kind the Nose-bones are as enormously large as in the *Tapiir*; they are small and arch over the aperture of the nostrils at a considerable height above the floor of the nose, extending as far forward or even beyond the extremities of the muzzle-bones; consequently the depth of the muzzle is very great. In the *Two* and *One-horned* (fig. 39. L.) species, the form of the two bones together is that of a long triangle, of which the base is connected with the nasal processes of the frontal bones by nearly a transverse suture; the sides are bent down specially near the base, and the hind angles truncated, so that they rest on the nasal plate of the lachrymal and upper jaw-bone, in front of which junction the front angle bends down towards the muzzle-bones. The protuberance on which the horn or horns rest, partly depends on the elevation of the upper table of the bone above the lower, the interspace being filled with bony cells, communicating with the frontal; but the lower table is also vaulted, though in a less degree than the upper. In *Burchell's Rhinoceros* (fig. 40.), these bones are of enormous size, forming a broad, deep, bony vault with very thick walls, which overhang the muzzle-bones both on their sides and extremity.

The Lower Jaw-bone (o.) in the *Swine* is very long; its horizontal branches, deeper behind than before, and with a thick rounded straight base, are early connected into a single piece at a sharp angle, in front of which their junction is continued at least a fourth of the entire length of the bone. So far forward as this angular connexion the branches are vertical and contain the molar teeth, but before it their upper edges, in which are the cuspid and incisive teeth, inclining outwards, they become oblique, splaying out the fore and upper part of the bone in an angular shape, whilst the under surface rises up suddenly at an angle with the base of the molar part. At the commencement of the eversion the sockets of the cuspid teeth project, the sides of the jaw producing an appearance of contraction between them and the molar teeth. In the *Babiroussa* these sockets are very large and prominent, and of great length, being continued beneath the roots of all the molar teeth back to the ascending plates. In the *Tapiir* the eversion of the front of the bone is slight, and in place of the deficient cuspid teeth the upper edge is very sharp, thin, and contracted; the front of the jaw expands, is rounded transversely, and beneath it forms a regular sweep with the base, which is convex. The ascending branches, of an oblong square, are about as tall as half the length of the horizontal, and much thinner; angular processes they have not, the lower hind ends of the bone being rounded; their hind edge is vertical, and terminated above in a transversely oval condyle, convex from behind forwards and from side to side, and separated each by a small gap from the corresponding low triangular coronoid process. In the *Babiroussa* the coronoid process is higher, and in the *Tapiir* still more lofty, stouter, and curving back slightly over the condyle. The Lower Jaw of the *Rhinoceros* kind differs little from that of the *Swine*, except in the greater comparative breadth of its condyles, and the front being thinner, flatter, and of more square form.



The *Hippopotamus*, next to the *Elephant*, has the largest Head of all Beasts, excepting some of the Whale Tribe; but it differs materially in being low and flat, in the great width of the temporal pits, and in the great length and lateral extension of the face, particularly in front.

The Occipital bone has its great hole very wide; the basilar process very wide, stout, and triangular; the condyles transverse, and facing directly backwards; the paramastoid processes are large and peg-like: the occipital portion is low, very wide, and vertical up to the crest, from the middle of which projects forwards a short thin angle between the hind upper edges of the parietal bones.

The Sphenoid bone has its body united to the occipital; it is wide and rounded beneath; the temporal plates short, flat, and nearly horizontal, do not rise up to form any part of the temporal pits; the external pterygoid plates are short, do not descend as low as the palate, and instead of a hooked process, have merely a small stud on the outer lower edge; the internal pterygoid plates are distinct bones, lie close within the former, without any intermediate pit, and are only slightly separated in front to receive the hind edge of the palate-bones.

Of the Ethmoid bone a small flat plate assists in forming the inner wall of the orbit, where it is inserted between the frontal, palatine, sphenoid, and upper jaw bones.

The Parietal bones form the largest part of the vault of the not very large Skull; the figure of each is a very irregular square, bulging in the middle; their hind edge splays upwards to perfect the greater part of the occipital crest; their inner raised edges joined in front of the occipital angle to form the single parietal crest, soon diverge, forming a large angular gap for the reception of the hind angle of the frontal bones, and are lost in the upper anterior angles; the lower edge of each bone is overlapped by the squamous plate of the corresponding temporal bone, and the lower anterior angle descends as a broad oblong elongation between the just mentioned bone and the temporal plate of the frontal bone.

The squamous plate of the Temporal bone of each side is remarkable for its resemblance to that of the *Elephant*, in that after having perfected the lower and back part of the temporal pit, its upper hinder edge sweeps considerably outwards above the external auditory aperture, so that a large portion of the temporal pit faces forwards, and is wider in this animal than in the

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*Elephant.* The width of the pit is still further increased by the great length of the outstretched trigonal glenoid process, of which the articular surface beneath is very large, oblong, and nearly flat, with a slight lip at its hinder inner edge, which is only separated from the paramastoid process by a thin plate descending from the under edge of the small auditory passage, which runs down to a large cellular drum cavity, at the base of the Skull. The mastoid process forms part of the occipital surface, and the occipital crest is continued down upon it. The zygomatic is continued from the outer extremity of the glenoid process forwards, but soon suddenly rises upon the zygomatic process of the cheek-bone.

The Frontal bones have a remarkable resemblance to those of the *Whalebone Whale*, their principal part consisting of a lengthened band-like frontal portion, which stretches outwards and forwards above the cavity of the orbit, and terminates in the semicircular brow-margin, with its well-defined angular processes. The temporal plate descending from the hinder edge of the Frontal to the parietal is small, triangular, facing almost directly backwards, but does not entirely separate the temporal pit from the orbit, of which the whole inside is formed by the orbitar plate of the frontal descending to the ethmoid, sphenoid, palate, upper jaw, and lachrymal bones.

The Cheek-bone is very large, massive, and deep, overlapping and lapping against the large malar process of the upper jaw-bone; its upper edge, deeply concave, forms the lower half of the orbitar margin, as the frontal bone forms the upper half; but the orbitar processes of the Cheek-bone do not touch the angular processes of the frontal bone, a very small portion of the lachrymal being interposed between them in front, and a small gap separating them behind.

The small portion of the Lachrymal bone, just mentioned, as perfecting the front margin of the orbit, expands and descends behind as the orbitar plate, which is squarish, nearly vertical, and has in it a large aperture leading to the nostril; the nasal plate, not very large, is immediately in front of the anterior angular process of the frontal bone.

The Nose-bones exhibit a remarkable contrast to those of the *Elephant* in their great length, reaching as they do to the very extremity of the muzzle, and in the great width of their hinder ends, which fill up the whole wide angular space between the front of the frontal bones, excepting the small portions occupied by the nasal plates of the lachrymal, with which, as also with the nasal plate of the upper jaw and muzzle-bones, their outer edge is connected; their inner edge joins them together, and their front end is square.

The Upper Jaw-bones are not very deep; the hinder tooth-sockets pass through the floor of the orbits half across the temporal pits. The palatine processes are long and narrow; an angular gap between their hinder ends receives the palate-bone, and a still longer and narrower gap in front receives the palate-plates of the muzzle-bones. The fore and outer part of each nasal plate spreads outwards considerably, and forms the socket of the large cuspid tooth, rendering the front end of the bone square.

The Muzzle-bones have long thin palate-plates, with small narrow Incisive holes between them and the upper jaw-bones. Their nasal-plate, long and deep, curves upwards and inwards to join the nose-bone, and its hind angle lengthening backwards runs into the angular gap between the nose and upper jaw-bone. The lower and fore part of this plate is enormously developed, externally and at right angle with the palate plate, into a large boss, lodging two incisive teeth, and which is situated before the socket of the cuspid tooth, and separated from its fellow by the thin edge of the palate-plates.

The Ploughshare bone is very slender, projects far forwards, and continued upon the palate-plates of the muzzle-bones, almost to their front edge. The pterygoid plates of the Palate-bones descending below the pterygoid plates of the sphenoid, form the outer lower margin of the square hind aperture of the nostrils; their palate-plates are largely concave behind, and their nasal plate is long, deep, and bulging a little outwards.

The Lower Jaw differs remarkably from that of the *Elephant*, in the great extent and squareness of its front or symphysis, depending principally on the enormous bony mass sent inwards from the front of the horizontal branch, to join its fellow, and lodge the middle two incisive teeth; but the outer and fore part of each bone is also considerably developed into a large socket, lodging the large outer cuspid tooth. The depth of the horizontal branch is considerable and its base very thick, but the vertical descends very far below it, so that the front of its angular process is at right angle with the base, whilst its hind part is rounded and much outspread. The coronoid process, thin and tall, rises above and much in front of the condyle, which is low, of triangular shape, nearly flat from without inwards, and lightly rounded behind.

(J.) The Solipeds consist of the *Horse* kind only, which, although placed by Cuvier among the Thick-skinned Beasts, in many respects, especially as regards the Head, much more nearly approach the Ruminating Order, and more particularly the *Camel* and *Sheep* kinds.

In the Occipital bone, the great hole is large and nearly square; its sides are lengthened considerably by the elongation of the trigonal condyles, which rise above the level of its upper edge, and nearly meet beneath; the basilar process is narrow and trigonal, with its base above, and hollowed transversely; the occipital crest, nearly square, projects much backwards; below it is an ill-defined pit for the attachment of the nuchal ligament, and before it the occipital angle projects between the parietal bones, and is ridged centrally from behind forwards to join the ridge at the junction of the parietal bones, and on either side a ridge descends to each squamo-mastoid bone to form the back of the temporal crests: the paramastoid processes are very long, thin, and vertical.

The Sphenoid, which is a distinct bone, has its temporal plates wide and elevated, rendering the base of the Skull wide by throwing out the lower edge of the squamous plates of the temporal bones; these plates also participate in forming the temporal pits, and with the temporal surface of the transverse spinous processes join the parietal bones above, and separate the temporal and parietal bones; the spinous process is short. The root of the external plate of the pterygoid process, as in this Order generally, is double, with the pterygoid hole passing through it from behind forwards, and opening in the front pit; the inner plate is thin and distinct from the rest of the bone.

The Parietal bones swell out laterally like those of the *Camel*, but are less lofty, comparatively shorter, and

their slight temporal ridges or crests run into one at the hinder part of the sagittal suture; their lower front angles do not descend to the sphenoid bone.

The Temporal bone, as in the *Sheep*, is divided into squamous, tympanal, and mastoido-petrosal portions. The scaly plate is large and semilunar, as in the *Camel*, but is entirely in front of the external auditory aperture, over which the ridge passing to the mastoid process is lengthy. The zygomatic process curves upwards, outwards, and downwards, and having reached the outer front edge of the deep articular cavity of the glenoid process, projects forwards and slightly downwards, short, deep, stout, and almost alone forming the zygomatic arch; after which it is depressed, and runs between the posterior angular process of the frontal and the zygomatic of the cheek-bone and the malar of the upper jaw-bone. The articular cavity is deeply concave before, the glenoid process descending very obliquely, but behind the lip is deficient, excepting the short stud at the root of the zygoma.

The frontal surface of the Frontal bones is slightly arched between their junction with the parietal bones and the front of the temporal pits, but is nearly flat between the orbits. The general form of this surface is triangular, with its base in front joining the bones of the face, and its truncated apex behind, from each corner of which the temporal ridge curves forwards and outwards to the hind angular process, which stretches far outwards, curves downwards, and, spreading at bottom, rests on the zygomatic process of the temporal bone, with it forming the hind margin of the orbit; the brow ridge stands well out, is regular, and renders the forehead very wide and the orbit deep. The temporal plate is not deep, but seems only bordering round the squamous plate of the temporal bone, and merely a slight rising marks its separation from the orbitar, which is deep and squarish, connected behind with the sphenoid, and below with the palate, lachrymal, and a very small portion of the upper jaw-bone.

The Cheek-bones are characterized by the absence of the superior orbitar process, consequently they do not join the frontal bone; the inner orbitar process is wide, specially in front, and, joining the orbitar plate of the lachrymal bone, forms with it all but the entire bottom of the orbit, excluding almost entirely the upper jaw-bone from the orbit; behind, it is continued as the zygomatic process a short distance beneath the zygomatic of the temporal bone. Its facial surface is large, squarish, and together with the malar process of the upper jaw-bone forms a sharp overhanging ridge on the side of the face, continued from the under edge of the zygoma.

The Lachrymal bones have their nasal plate irregularly square and deep, interposed between the upper jaw and frontal bones; their orbitar plate is L-shaped, with both limbs wide, and the orbitar plate of the frontal received in their intervening angle; their lower edge rests on the cheek-bone, as already mentioned.

The Upper Jaw-bones are very long and very deep, to give room for the large sockets of the constantly-growing molar teeth. The nasal plate inclines from the teeth upwards and inwards to its lengthy junction with the nose-bone; its hinder under part is continued as far back as the middle of the orbit, and terminates in the tuberosity; but above, it reaches only to the facial surface of the cheek bone, entirely conceals its outstanding malar process, running back to the zygomatic process of the temporal, and to the nasal plate of the lachrymal bone, which covers the gap in the bone above the malar process, whilst the orbitar plates of the lachrymal and malar exclude from the orbit that part which is continued below it, except a very small piece which appears in the angular gap between the hinder edge of those two bones. Its front descends obliquely forwards to a point. The palate-plates are lengthy, largely cut away behind for the reception of the palate-bones, but less deeply in front, to receive the long and wide palate-plates of the muzzle-bones. The tooth-sockets are deep and capacious, extending as far forwards as a line dropped from the hind part of the nasal aperture; but between them and the muzzle-bone the conjoined edge of the palatine and nasal plates is sharp and toothless.



The Palate-bones have their palate-plates as simple narrow bands running forward within the roots of the hinder tooth-sockets, and, bending inwards in front to their junction, form between them a large semi-elliptical gap. The naso-orbitar process joins by its hinder upper edge to the sphenoid and frontal bones.

The Muzzle-bones are long, and have great general resemblance to those of the *Tapiir*, but their nasal plate is less lengthy; its hind end runs a little way in between the upper jaw and nose-bone; it deepens as it stretches forwards, and its upper edge is rounded; its lower and fore part runs inward to join its fellow and perfect the front of the nasal aperture; it is very deep and thick to lodge the incisive teeth, and is rounded in front. Its palate-plate is long and flat, and stretching back into the gap of the upper jaw-bone: the incisive hole is long and very narrow.

The Nose-bones are of considerable size; their hinder ends are very wide, and separated by the projection of the nasal processes of the frontal bones; their front surface is flat and nearly straight from the frontal bones to the external aperture of the nostrils, but the outer side of each bends downwards and outwards to join the upper edge of the lachrymal, upper jaw, and muzzle bones. Having reached the nasal orifice, the sides and upper surface of the bones gradually narrow till they terminate in a point, and as they proceed forwards curve slightly downwards, but their tip is far distant from the muzzle-bones, consequently the aperture of the nostrils is very large. The curving of these bones over the nostrils resembles that of the same bones in the *Rhinoceros*, but in a less degree.

The Ploughshare bone is long and shallow; it is visible within the gap of the palate-bones, but passes before them to join with the nasal ridge of the upper jaw-bones.

The Lower Jaw is of great length: its horizontal branches join in front at a very acute angle, and their junction is continued far forwards; whilst supporting the molar teeth they are vertical and deep, but in front become very shallow, and their upper sharp edge is not higher than the bottom of the molar sockets; at this part the jaw is much contracted and does not contain teeth, but in front it spreads out in a semicircular form with the edge everted, and supports the incisive teeth. The ascending very thin branches are very tall, and wide from behind forwards at the base, where the angular processes are rounded, but narrowing above; their hind edge is thick, and terminates above in the transverse condyle, which is convex from side to side, but more convex from behind forwards, and separated in front by

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a slight concavity from the thin and slender coronoid process which rises upwards and a little backwards, but does not at all overhang the condyle.

(K.) The FOUR-HANDED OF QUADRUMANOUS Order includes the two large families of Lemurs and Monkeys, which have their hind feet converted into hands, by being furnished with thumbs. The cavity of the skull is larger in these than in other animals; the margins of their orbits perfect, and their plane forwards, and more or less vertical.

(*.) The Lemur Family lead, by the *Flying Macauco*, *Galeopithecus volans*, in which the orbitar margin is still imperfect and the face long, from the Insect-eating Predatories to the Monkeys, through the *Indris*, *Lichanotus*, which, with the ring of the orbit perfect, have the face shorter. The general characters of the Head in this Family are, the much greater capacity of the skull, its greater width across the temples, and projection behind the apertures of the ears, together with the absence of paramastoid processes; the large size of the widely separated orbits, and their direction much, though not immediately, forwards.*

The Occipital bone in the *Ring-tailed Lemur*, *Lemur catta*, has a wide basilar process; the great hole nearly round, and the compressed condyles rising a little above its transverse diameter; the paramastoid processes disappear, and the occipital surface, vertical, or inclined a little backwards to the slightly developed occipital crest, is convex transversely, and has in its middle a vertical prominence indicating the position and size of the vermiform process of the cerebellum; above, the crest projects upwards and forwards a smooth triangular surface between the hind edges of the parietal bones. The general form of the bone is hexagonal, with the sphenoidal angle below, the occipital above, and a parietal and temporal angle on each side, the latter taking place of the paramastoid process. The front concavity of the bone is marked by the crucial ridge, with its grooves for the sinuses, and the deep vertical pit for the cerebellar vermiform process. In the *Flying Macauco* (Pl. V, fig. 41), the basilar process is narrower, the occipital surface lower and wider, and the occipital ridge more distinct; but in the *Crowned Indri*, *Lichanotus diadema*, the occipital surface is more rounded.

The Sphenoid bone in the *Lemur* remains divided. The body of its occipito-sphenoidal portion is wide behind, and narrows in front; its Turkish saddle is a shallow cup with raised edges; its temporal plates are low, but spread widely outwards, rendering the bone very broad, and the spinous processes stretch backwards nearly square; the pterygoid processes are far apart, and each pair of plates separated by a narrow pit; the inner pair are nearly vertical, short, but deep, with long hook-processes; the outer pair, inclined outwards, are long but shallow, and their hind edges nearly square. The body of the ethmoido-sphenoid is wide, and beneath it are a pair of cells; its transverse spines, large, triangular, and nearly flat, form the back and upper part of the orbits.

The Ethmoid bone in this animal is wedge-shaped, with its base or sieve-plate behind, nearly circular, and divided by a thin cock's-comb. In the *Lori*, *Stenops gracilis*, this bone is sharp above, and spreads out beneath, and its convolutions are bounded externally by the large flat plates which form a large part of the inside of each orbit.

The Parietal bones, large and squarish, form the greater part of the vault of the skull, and swell out more behind than in front; their hind edges diverge to receive the upper angle of the occipital bone; the lower edges, nearly straight, rest on the temporal and sphenoid bones, with scarcely any overlapping of the former, and their front edges project a little process from each, which abuts on the hind angular process of the frontal bone. The temporal ridges commencing from the parietal angles of the occipital are not very distinct, and curve slightly forwards into the hind angles of the frontal bone; the space between them is wide and smooth. In the *Flying Macauco* this coronal space is smaller and squarer, the temporal crests more sharp, and the temporal surfaces more flat and oblique, instead of being rounded, as in the *Lemur*.

All the portions of the Temporal bone (n.) are early consolidated in the *Lemur*. The squamous plate is long, low, and runs back into the mastoid portion, which assists in forming the back of the skull, but of which the process is very small and flat; the glenoid process does not jut out much, therefore the temporal pit is narrow; but the articular surface beneath it is wide, flat, and bounded behind by a deep thin lip; the zygomatic process, short and slender, stretches almost directly forwards. There is not any auditory tube, but the drum vesicle, large, as in the *Cats*, completely excludes the petrous portion from the outer surface of the skull, and has a little pointed process in front, which laps within the outer pterygoid process of the sphenoid. In the *Flying Macauco*, the mastoid process is largely developed, and the occipital ridge descends to terminate on it; the glenoid process stands well out, and the articular surface beneath it is wide, concave from behind forwards, and has a deep concave hind lip, to the inner side of which is the not very large drum vesicle; the zygomatic process is deep and strong; its upper edge inclines outwards, and extends backwards like a ledge above the aperture of the ear to the occipital crest. In the *Crowned Indri* it is much more slender and vertical, nor does it extend back beyond the aperture of the ear, which is large, as is also the drum vesicle.

The Frontal bones, a pair, are in the *Lemur* soon united by their inner edges; the frontal surface, slightly arched transversely, is triangular, with its base behind and the basal angles lengthened outwards beyond the parietal bones, compressed and curved downwards to form the posterior angular processes; the side edges form the sharp brow-ridges, and these terminate in the suddenly descending front angular process; the front angle is truncated, and joins the nose and upper jaw-bones; the orbitar plates, triangular and concave, facing forwards and outwards, are widely separated by the ethmoidal gap, though there more approached than in front: temporal plates are deficient, the parietal bones extending to the very orbits, and indeed slightly turning into them. In the *Slender Lori* (fig. 42.), the Frontal bone is pentagonal, with its base behind, and its side edges received within the parietal bones; its front curving edges, forming the brow-margins, very sharp, thin, and elevated, curve with very little inclination backwards into the outer angular processes, which project outwards and downwards, broad and thin, so that the plane of the orbits is nearly directly forwards and upwards; their

* The general description is from *Lemur catta*.

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roots behind form the very small part of the bone which assists in perfecting the temporal pit. The inner angular processes, very thin, run into each other, and form the sharp inter-orbitar space, which is a mere thin plate, so that between the eyes the space is very small; below, it spreads slightly to form the nasal process, which descends below the horizontal diameter of the orbits, and receives the nose-bones. The insides of the orbitar plates are close together, and form a simple partition between the cavities, their lower edges only diverging slightly to receive the upper edge of the ethmoid bone. In the *Flying Macauco* the frontal surface is wider than in the *Lemur*, and its front angle more largely truncated: the posterior angular processes are shorter, more horizontal, and project more backwards than downwards, consequently do not reach the cheek-bones, as in the *Lemur*.

The principal and crescent-shaped part of the Cheek-bone forms in the *Lemurs* the outer under part of the orbitar margin; their hind orbitar process, flattened from within outwards, being united with the outer angle of the frontal bone, and their front orbitar flattened obliquely from behind forwards, and resting on the malar process of the upper jaw-bone, reaches inwards to the lachrymal. From the crescent extends backwards the slender zygomatic process, which joins the corresponding one of the temporal bone, and perfects the zygoma; the bone is deepest between this process and its junction with the upper jaw-bone, and from its obliquity forms the outer side of the floor of the orbit; but the cavities of the temporal pit and orbit freely communicate. In the *Flying Macauco* the hind orbitar process does not rise above the level of the deep zygomatic process, of which it forms only the angular root, consequently a very wide gap separates it from the angular process of the frontal bone; but much more of the floor of the orbit is formed by the bone than in the *Lemurs*.

The Lachrymal bones, which, with the two preceding bones on each side, perfect the orbits, are in the *Lemur* of triangular form, the narrow orbitar process being separated by a vertical ridge from the large nasal process, of which the upper edge joins the lengthened nasal process of the frontal bone, and the under edge with the nasal of the upper jaw-bone, and has the nasal duct perforating it.

The Palate-bones are, in the *Lemur*, remarkable for the splitting of their orbitar process about its middle into a pair of plates, the outer one inclining outwards, and perfecting the plate itself, connected above with the frontal; below, with the upper jaw-bone; and before, with the lachrymal; the inner one continued directly forwards as the nasal plate, and thus leaving between them an angular gap, which forms the back of the large palato-maxillary cell: the palatine plates are of moderate length, but in the *Flying Macauco* they are short.

The Upper Jaw-bones are lengthy in the *Lemurs*; their nasal plate rising upwards and inwards, triangular, with the front angle truncated and swollen by the bottom of the socket for the large cuspid tooth; the palate-plates are wide, and the sockets for the molar teeth, wide, are continued far behind them; the malar process has a very lengthy root, and projecting much outwards, its upper surface, with the roots of the last two molar teeth, form the floor of the orbit: between the upper outer edge of the palate-plate and the roots of the front tooth-sockets a thin plate gradually rises up to the inside of the nasal plate, and forms the front of the palato-maxillary cell, leaving, however, a large aperture between them, which is partially closed by the hind end of the long Turbinated bone. These bones are shorter in both the *Crowned Indri* and the *Flying Macauco*.

The Muzzle-bones have large and tall nasal plates, through which the cuspid tooth-sockets pass in both animals; their palate-plates are also large, and the pair of incisive holes are entirely formed by them, and the tooth-sockets in front of them are extremely small.

The Lower Jaw consists of a pair of long horizontal branches, of which the junction in front is much under-cut; the ascending branches are not tall: in the *Lemur* the angular processes are moderately developed, and the condyles, transverse and nearly flat, have the thin coronoid processes rising before them at right angles. In the *Flying Macauco*, the condyles are much in front of the rounded angular processes, and their articular surfaces nearly on a level with the top of the short and small coronoid processes.

(**.) The Monkey Family are most remarkably distinguished from all other Beasts by the perfection of the orbits, resulting from the increased development of the inner orbitar plates of the cheek-bones, which, continued backwards and inwards, join the front edge of the large orbitar plates of the sphenoid bone, and unite with the orbitar plates of the frontal above, and the upper jaw-bones below. Thus, the orbitar cavities are completely separated from the temporal pits, excepting at the spheno-maxillary cleft, which varies much in length, but is never of great size. The plane of the orbitar openings is, in these animals, almost directly forwards, but varies in its verticality very considerably. The transverse arch of the Skull in the region of the parietal bones is lofty, and the frontal surface of the frontal bone generally descends from it to the orbits, and is more or less prominent. The plane of the great occipital hole faces more downwards, and the back of the Skull projects above and behind it, with few exceptions; and the condyles, which are small, assume the same direction. The mastoid parts of the temporal bones largely participate in the formation of the hind head, but their mastoid process can scarcely be said to be developed. In some kinds, large occipital and temporal crests exist, and these, during their progress to perfection, alter the characters of the Skull so remarkably that it is with difficulty it can be believed the Skull which, whilst young, has so near resemblance to that of man, excepting its diminished size, should assume so different a figure, as happens in many instances. The length of the Face is very variable, but always do the jaws project before the vertical plane of the orbits, and the lower jaw has no chin or projection of the front of its base.*

The Occipital bone has the plane of its nearly circular great hole facing downwards and backwards; the basilar process, rather longer than its width, rises a little upwards; the occipital part ascends backwards at a very open angle with the just-named process, and is nearly flat, except at its parietal and occipital angles, which curve slightly forwards; on its front is the grooved crucial ridge for the sinuses, with the three cavities for the cerebellar lobes and vermiform process below, and the two cavities for the cerebral lobes above it: on its back the transverse occipital ridge or crest is not very distinct; but a well-marked vertical ridge descends from

* The general description is from *Cercopithecus sabæus*.

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its middle to the hind edge of the great hole, with a shallow pit on either side. The condyles are not very large, but face downwards, and curve on the sides of the great hole, but are well separated in front. In the *Sajou, or Squirrel Monkey, Callithrix*, the occipital surface stretches obliquely upwards and backwards to its horizontal crest, below which are a pair of deep muscular pits, and above it the bone stretches nearly horizontally backwards, convex beneath, and concave above towards the skull cavity; hence the back of the Head projects far behind the spine when the animal is upright. On the contrary, in the *Thumbless Monkeys, Ateles*, the occipital surface, slightly rounded, rises nearly vertically above the basilar process and occipital hole; and in the *Howlers, Mycetes*, the condyles, occipital hole, and surface are all vertical to the basilar process. In the *Orangs, Pithecus*, the basilar process, broad and square, is nearly horizontal; the condyles, small, facing backwards and downwards, are convex laterally and upwards; the occipital hole has the same direction, but is rather more vertical: the occipital surface is nearly square up to the occipital ridge; in the *Bornean* species it is flat and vertical, but in the *Sumatran*, more convex both transversely and vertically; in the former the occipital ridge is sharp and strongly developed, but in the latter less so; the protuberance is very decided, and the angular space in front of the former very distinct, but in the latter it scarcely follows the vertical curve. In the *Chimpanzee, Troglodytes*, the occipital hole is more horizontal, but still facing backwards: the occipital surface, arched laterally and transversely, nearly as in the human subject; the occipital ridge, not very strong, forms a pair of small arches, the inner ends of which spring from the protuberance, which is very similar to that in man; and above these ridges the triangular part, continued between the hind edges of the parietal, is much larger and more vertical than in other Beasts. In the *Mandril, Papio*, the occipital crest is largely developed, and overhangs considerably the occipital surface; the inter-parietal angle is short and sharp.

The Sphenoid bone consists of two pieces. The occipito-sphenoid portion is very capacious; its body, wide behind, but deep and narrow in front, has, on its upper surface, a well-marked Turkish saddle without side edges, but overhung behind by a large square posterior clinoid process. On each side of the body are the large cavities for the middle lobes of the cerebrum, bounded laterally by the large temporal plates, which are convex externally, and have their lower hind ends lengthened backwards as the spinous processes; in front, are the nearly flat orbitar plates facing forwards and inwards, with well-defined lower edges, forming part of the spheno-maxillary clefts in the orbits. The pterygoid processes have their pairs of plates united in front at a sharp edge to join the backs of the palate-bones; behind, the outer plates, which are very large and square, stretch outwards; but the inner plates, much narrower and with short horizontal hook-processes, pass directly backwards, and thus, between each pair, is formed a large pterygoid pit. The ethmoido-sphenoid portion, soon consolidated with the frontal bone, has a short, narrow, deep body, with its lower edge keel-shaped for the reception of the base of the ploughshare bone; its transverse spines, small and short, have in their roots the optic holes. In the *Mandril*, the temporal plate rises up in angular form between the temporal and frontal bones; but does not reach the parietal. In the *Chimpanzee* it forms a narrow, vertical surface similarly circumstanced; but in the *Orang* it is wider, does reach the parietal bone, and separates the temporal from the frontal bones; its hind edge in the two latter kinds is vertical down to the root of the pterygoid process. In the *Squirrel Monkey* and in the *Howlers* this plate is short, square, and also separates the temporal and frontal bones.

The Parietal bones are large and irregularly square, with the front lower angle truncated, their lower edge longest and their hind edge shortest; the front edges diverge widely for the reception of the frontal bones, and the hind edges for the occipital bone. In the *Mandril* the temporal crest commences singly from the fore and upper angle of the occipital bone, and appears on the hind edge of the parietal single, but soon splits into two, not very strong, which diverge, enclosing between them the narrow triangular coronal surface, the front edge of which joins the back of the frontal bone; the temporal part of each is continued forwards about half an inch beneath the edge of the frontal surface of the frontal bone, and joins by its front edge with the temporal plate of that bone, and by its lower square angle with the sphenoid, thus separating the temporal from the frontal bone. In the *Orang* the temporal plates occupy the whole surface of each bone, are very convex from behind forwards, and from above downwards, and splay out a little at their lower edge; they are also continued below the hind part of those of the frontal; the temporal crest is single throughout, strong, and very deep behind. In the *Howlers* the whole front edge of each bone is uninterrupted; the coronal surface is wide, and, except at the back, where it is widest, nearly of equal breadth throughout, the well marked, though not very elevated, temporal ridges passing nearly straight forwards; it is arched from behind forwards; the temporal plates are convex vertically, and deep. In the *Chimpanzee* the front edge descends from the upper angle of each bone vertically to the inferior angle, which stretches forwards a little beneath the temporal plate of the frontal; the coronal surface rises arching much forwards, and is wide behind, but slowly narrows to the top of the skull, whence it continues forwards of equal breadth to its junction with the frontal bone. Temporal crests are deficient, but the extent of the temporal plates is marked by their upper boundary dropping a little below the coronal surface, so that a slight groove is formed instead.

The Temporal bones have their several portions early united. The squamous plate is very shallow, and is continued back, with a nearly straight upper edge, to the flat mastoid part, which helps to form the back of the skull, and has little or no mastoid process. The glenoid process and temporal pulley are wide, and the articular surface beneath very spacious and flat, has a deep hind lip. There is not any bony external auditory passage; and the drum-ring, facing outwards and downwards, is large. A large rounded process below and before it indicates the position of the cochlea of the ear, behind and within which the petrous portion appears in the base of the skull. In the *Mandril*, and also in the *Chimpanzee*, the front angle of the bone projects upwards in a square form between the sphenoid below and the parietal above, and joins the frontal bone; but in the *Orang* the temporal plate of the sphenoid separates it from the frontal. The glenoid process is wide, and stands well out in both *Mandril* and *Orang*, though

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less in the latter; the articular surface for the lower jaw is in both concave from side to side: in the *Mandril* slightly convex and broad from behind forwards; but in the *Orang* it is nearly square, very spacious and flat; in both its hind edge is guarded by a little descending triangular lip. In the *Chimpanzee* the glenoid process is less wide, the articular surface concave from side to side and from behind forwards, but it has not any hind lip, and the back of the joint is therefore bounded by the external auditory passage of the temporal bone. The zygomatic process in the *Orang* is very stout and prismatic, with the base beneath; from its root it curves a little outwards, and then forwards and inwards, to overlap the corresponding process of the cheek bone, deepening as it continues forwards. In the *Mandril* it has the same form, but is less stout and curved. But in the *Chimpanzee* the zygomatic process is very thin, slender, and is continued forwards and a little inwards, and passes within the corresponding process of the cheek-bone.

The Frontal bone is, with a few exceptions, distinguished from that of all the other Orders by the height of its frontal part, and by the nearly transverse direction of its brow-ridges, in consequence of which the angular processes hitherto described as front and hind are now inner and outer. The lofty frontal surface rises from the brow-ridges upwards and backwards convexly, and convex also transversely, to its hind edge, of which the highest angular part is received between the front edges of the parietal bones. From each outer angular process curves upwards and backwards the slight temporal crests, separating the temporal pits from the forehead. The brow-ridges are well defined and convex, with rounded edges, separated in the middle by the narrow but lengthy nasal process, at the root of which are the indistinct inner angular processes; the outer ends of the ridges terminate in the fully developed and laterally compressed outer angular processes. The orbitar plates, concave from side to side in the orbits, and correspondingly convex towards the cavity of the skull, are nearly horizontal, and separated by the long narrow ethmoidal gap, which extends from the back of the nasal process to the sphenoid-bone, and contains the narrow sieve-plate, which has not any cock's-comb, but has below a very deep partition-plate. This, which hitherto has belonged to the ethmoid bone, seems here to be truly a part of the frontal itself. The whole hind edges of the frontal part join the parietal bones to the level of the outer angular processes, the hind edges of the orbitar plates with those of the sphenoid bone, and their inner lower edges with the flat plates of the ethmoid, and the nasal process with the lachrymal, upper jaw, and nose bones. Not all this great Family have, however, the Frontal bone as already described. In the *Mandril* the frontal surface is very nearly on the same plane as the coronal surface of the parietal bone, and its brow-ridges are elevated above it, so that the forehead is actually rather concave; its parietal or hind angle is largely truncated, and received on the front edge of the parietal, the temporal plates of which are continued forwards at least half an inch along the temporal crest, which to this extent is formed by both bones; the front of the temporal crests, formed by the frontal bone alone, are very sharp and stretch outwards into the outer angular processes; the temporal plates are not large, and face backwards and outwards. In the *Orang* the hind edge of the frontal bone is more extensive, and the under-running of the parietal bones is very far below the temporal crests, which, commencing at the middle of the hind edge from the single crest of the parietal bones, stretch outwards and downwards to the middle of the brow-ridges, but, not quite reaching them, curve outwards into the external angular processes, leaving between them the flat triangular frontal surface, of which the plane, like that of the whole face, is obliquely downwards and forwards. In consequence of the angular origin of the temporal crests the temporal plates are very large, and a considerable portion of them is convex outwards, whilst their concavity is only behind the angular processes. In the *Howlers* the whole hind edge of the frontal bone is regular, and not intruded on by the parietal bones; the frontal surface curves regularly, but not very deeply, down to the brow-ridges, is smooth and lightly arched transversely, and bounded on each side by the continuation of the well-marked but not very prominent temporal crests, below which the temporal plates, not very large, are contracted between the cavities of the skull and orbits, but both are convex vertically; whilst in the *Orang* the orbitar part is flat, and in the *Mandril* concave, owing to the breadth and backward inclination of the angular processes. In the *Chimpanzee* the hind edge of the bone is nearly the same as in the *Howlers*, but the frontal surface continues comparatively further forwards, nearly on the coronal plane of the parietal bones before it curves, and then descends more suddenly, forming a low forehead, which terminates behind and not in the brow-margins. The frontal surface is slightly arched, and wider than in the *Howlers*; the temporal ridges are at first little more than slightly raised lines, and, even when they diverge opposite the middle of the brows to run into the angular processes, are only little sharp edges. The orbitar part of the temporal plates are much more convex vertically, and wider from within outwards, than in the *Howlers*. As to the brow-margins, they are in the *Mandril* projecting, rounded, nearly horizontal, and overhang the orbits: their short inner angular processes drop perpendicularly, and the intervening very short nasal process is deeply cleft to receive the nose-bones; the outer angular processes are broad, short, and face outwards and forwards. In the *Orang* the brow-margins are very thick, much arched, and little projecting above the plane of the forehead and face, except upon the roots of the inner angular processes, which swell and are only divided by a narrow groove, and the processes themselves descend as low as the transverse diameter of the orbits, having the cleft nasal process between them; the outer angular processes are flat forwards and wide, so that they much add to the breadth of the upper part of the face. In the *Howlers* the brow-ridges are less arched and wider, but sharp; the root of the nasal process, between the inner angles, broad and transversely convex; the outer angular processes are of moderate length, flat, facing a little outwards, but not very wide. In the *Chimpanzee* the brow-ridges are slightly arched and have thick edges; they project much before, and are elevated a little above, the bottom of the frontal surface, so that a distinct depression exists behind each, and their projection forwards is to such extent that the plane of the aperture of the orbits is nearly vertical. The inner angular processes drop perpendicularly, and the interposed nasal process is very wide, but nearly flat, and widely cleft below for the nose-bones; the outer angular processes, rounded

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Zoology. in front, become thinner as they descend and join the cheek-bones, which is the reverse of their condition in the *Orangs*, and their hind edge is very sharp and well defined. The extent of the ethmoidal gap is not of equal length and breadth in all this Family; in *Cercopithecus sabæus*, as already mentioned, it is long and narrow, but in the *Purple-faced Monkey*, *Cercopith. latibarbatus*, or the *Squirrel Monkey*, *Cebus sciureus*, and others, the very short gap is immediately behind the back of the nasal process, and the junction of the inner edges of the orbitar plates coalesce, and form a sharp keel, which does not reach the ethmoid bone. On the contrary, in the *Howlers*, in the *Chimpanzee*, and others, in which the ethmoid bone is large, the ethmoidal gap is large also, and the orbits widely separated.

The Ploughshare and Ethmoid form a single bone; the base of the former, which is cleft, receiving within it the keel of the sphenoid bone, and its lower edge jutting forwards, and resting on the united palate-plates of the upper jaw-bones. From the sides of its base projects the Ethmoid bone, the principal parts of which are its large flat plates, forming the insides of the orbits between the frontal above and the upper jaw-bones below; and from their inner surface stretch forwards a few simple convolutions, separated by the wide cleft into which the partition-plate of the sieve descends. The width of the Ethmoid bone varies as just mentioned; when wide, its flat plates join the inner edge of the orbitar plates of the frontal, from its nasal process back to the sphenoid bone; but in others in which it is small and little developed, it is connected only by the lachrymal bones and nasal processes of the upper jaw-bones, which together form a funnel, giving passage to the olfactory nerves; this may be seen in both the *Purple-faced* and *Squirrel Monkeys*, and especially in the latter. A little thin process rises up behind the funnel, from the Ethmoid to the frontal bone, but the greater part of its flat plates incline towards the mesial line, and form a low ridge, leaving a large gap in the bony partition of the orbits, which is filled in the recent state with ligament.

The Cheek-bones each principally consists of the large vertical, inner, orbitar process, concave from above downwards towards the cavity of the orbit, of which it forms the outer wall, and convex externally where forming the front of the temporal pit; its curved, thick, front edge assists in the orbitar margin, and of this, the lower and upper ends are the lower and upper orbitar processes; the upper edge of the inner process joins the corresponding outer edge of the orbitar process of the frontal bone: its back, with the corresponding edge of the sphenoid and the front of its lower edge, jagged, rests on the malar process of the upper jaw-bone, whilst the hind part of the same edge, free and rounded, assists in forming the spheno-maxillary cleft. From the outside of the lower orbitar process descends and stretches outwards and speedily backwards the slender zygomatic process to join that of the temporal bone, and form with it the zygomatic arch. In the *Mandril*, and still more in the *Orang*, the facial surface of the Cheek-bone looks obliquely downwards and forwards, and is very deep; in the former, its strong trigonal zygomatic process turns directly back from its root, but in the latter it curves outwards and slowly backwards to join the corresponding process of the temporal bone, and thus renders the temporal pit very wide. The lower orbitar process does not stretch far inwards in either, but is very deep in the *Mandril*; the upper process is broad in both, but especially broad in the *Orang*, and very tall, so that, in this animal, it renders the orbit vertically oval. In the *Howlers* the facial surface is deep, oblong square, facing a little outwards, and flat, as is also its upper orbitar process, which is tall but not very wide. In the *Chimpanzee* the facial surface is forwards and a little outwards. Its lower orbitar process stretches more inwards, and renders the orbitar opening wide; the upper process rises vertically and nearly at right angles from it, but is not very tall; it is very narrow, and its outer edge is sharp and turned a little back into the temporal pit; its zygomatic process is thin, deep at its root, but thinning as it curves suddenly backwards, so that the temporal pit is not very wide. Zoology.

The Palate-bones are of small size; each has a square palate-plate, on the outer edge of which rises the slender nasal plate, and behind it the sphenoidal process, of which the back joins the pterygoid process of the sphenoid, and the outside the upper jaw-bone.

The Muzzle and Upper Jaw-bone, on each side are early united; the former with its fellow forms the curving front of the upper jaw, and supports the incisive teeth alone, whilst the latter pair form the sides of the jaw, and contain the cuspid and molar teeth. The principal part of the Upper Jaw-bone consists of a large cavity beneath the large triangular orbitar plate which forms the floor of the orbit, joins by its inner edge the flat plate of the ethmoid and lachrymal, and by its rounded outer free edge perfects the palato-maxillary cleft. The tip of the sockets of the molar teeth forms the bottom of this cavity, which has a large aperture into the nostril partially filled below by the hind end of the long but very simply convoluted Turbinated bone. The nasal process, forming the front of the bone, has its base occupied by the large socket of the cuspid tooth, above which it rises in a lengthened triangular form, perfecting the inner margin of the orbit; hollowed behind where forming with the lachrymal bone the nasal duct, and straight in front at its junction with the nose-bone; and its upper jagged end joins the frontal bone. The palate-plate stretches horizontally inwards from the roots of all the tooth-sockets, except the hinder two, where it is deficient for the reception of the palate-bones. In the *Dog-faced Monkeys*, *Cynocephalus*, and in the *Mandril* especially, the Upper Jaw-bones project enormously, and nearly at right angle with the plane of the orbitar openings. The long nasal plate stretches forwards from the root of the malar process, and is vertically hollowed externally by the overhanging of the long rounded protuberance, which, commencing almost immediately before the lower edge of the orbit, terminates on the side of the aperture of the nostril; a wide and deep concavity on the upper surface separates the protuberances of the two bones from each other, along the middle of which passes the rounded nose-bones, and, from the hinder end, rises up the short and sharp nasal process; the malar process stands out, but not very far. The sockets for the large cuspid teeth project a little laterally on the front part, and between them are the wide Muzzle-bones, convex in front. In the *Orang* the Upper Jaw is considerably developed; its malar process is very deep, flat, and spreads far outwards; and in front of it the nasal plate, facing outwards, and of triangular form, rises upwards; but its nasal process, instead of continuing in the same plane, turns inwards and is only separated from its fellow by



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a narrow gap for the nose-bone; its front edge, forming the side of the triangular nasal aperture, is widened by the thick socket of the euspid tooth, which is separated from its fellow by the wide and nearly flat Muzzle-bones. In the *Chimpanzee* the form of this Jaw-bone is nearly the same, but the nasal plates are less long and more vertical; the nasal process less flat; the sockets of the cuspid teeth, though much smaller, are more defined, and the front of the Muzzle-bones is more rounded and less wide; the malar process is also less projecting and the edge of the orbit sharper.

The Lachrymal bones, concave from above downwards, and of square form, are entirely within the orbit, and their front upper angle rather sunken to complete with the jaw-bone the nasal duct.

The Nose-bones very early unite into a single piece, of which the front surface, slightly convex transversely and concave from above dowowards, is a lengthened triangle with its narrow upper end thrust up into the frontal bone between its inner angular processes, and its lower wider part forming the top of the aperture of the nostrils; a deep lip passes back from either of its side edges, which are received within the upper part of the nasal processes of the upper jaw-bones. The principal variation in the Nose-bones relates to their size and length; in the *Howling Monkeys* they are large, slightly arched transversely, and very broad, so that the square aperture of the nostrils is rather wider above than below; in the *Orangs* they are of moderate length, but together form a long and narrow triangular plate, generally flat, but just above the nasal aperture slightly concave transversely; in the *Chimpanzee* they are shorter and a little wider; but in the *Mandril* they are of considerable length, in accordance with the length of the upper jaw-bones, and wide at their root; they are rounded transversely, except just behind the nasal aperture, and in their course form a distinct rounded ridge in the deep cavity between the protuberances of the just-named bones.

The Lower Jaw-bone has the front of each deep horizontal branch inclined inwards at a nearly right angle with the side, to join very early its fellow, and form a flattish straight front, which inclines backwards from the top of the tooth-sockets to the base of the jaw, so that although the incisive teeth are nearly vertical, yet the under-cutting of the base throws their crowns forwards, and renders them and the front of the mouth projecting before the face. The side parts of these branches are wider above, where forming the tooth-sockets, than at their rounded base. The ascending plates are comparatively thin, not very tall, but wide from behind forwards; their angular process is rounded; the condyles transverse, convex from behind forwards, with the inner end overhanging the branch; a little notch separates them from the low thin coronoid processes which curve backwards, but their points only slightly overhang the notch. In the *Howlers* the ascending branches are much everted and of great size, reaching nearly to the middle of the bone, and projecting far behind the roots of the condyles; their angular processes are rounded. In the *Orangs* the ascending plate is very large and square, as is also the front of the deep horizontal branches. In the *Chimpanzee* the ascending branches are shorter, narrower from behind forwards, and more slender, and the horizontal branches longer, but less deep and powerful.

3. Of the Chest.

The Chest of Beasts differs from that of Birds in the breast-bone being narrow and lengthy, but not extending far upon the belly, the sides of which only as far as the loins are protected by the false ribs, and these becoming shorter and shorter towards the hip-girdle, form between their lower extremities a triangular gap, of which the base is backwards, and the point at the hind end of the breast-bone. Neither in Beasts are there, as in Birds and Reptiles, any false ribs in front of the breast-bone; for, as has been already observed (p. 333), the so-called anterior false ribs of the *Sloths* are in reality but movable transverse processes of the lower neck-vertebres. The ribs of Beasts, at least a large proportion of the hinder ribs, are also very movable, and, by the elevation and outspreading of their lower ends during inspiration, materially increase the diameter of the Chest. The form of this important cavity varies considerably, and depends principally on the number of pairs of ribs and their curvature. It is longest in the *Unau* or *Two-toed Sloth*, which has twenty-four pairs of ribs; but, with this exception, the greatest length occurs among the Pachyderms and Solipeds, in the former of which Orders the *Cape Daman* has twenty-one, the *Elephants* twenty, the *Rhinoceros* and *Tapiir* kinds twenty or nineteen; and in the latter, the *Horse* kind have eighteen pairs of ribs, as among the Cetaceans have also the *Dugongs*. On the contrary, in the Wing-handed Order, as the *Bats*, *Rousettes*, &c., and in the Four-handed Order, including the *Lemurs* and *Monkeys*, the Chest is short, the number of the pairs of ribs varying between thirteen and eleven. The Chest is, in the Cetaceans and in most of the large Pachyderms, very wide transversely, and in the latter nearly barrel-shaped, as in the *Elephant* and *Hippopotamus*; or it is narrow transversely and deep, as in the Ruminators, in the Solipeds, and most Predatory Beasts; but among the latter, as in all the *Weasel* and *Otter* kinds, it is more round, and of great length, although the number of ribs rarely exceeds fourteen pairs, and hence such are called Vermiform Beasts.

The Ribs vary also as to their size and shape otherwise than in reference to their curvature, and generally the first is broadest. In Ruminant Beasts, especially in the *Ox* kind, they are compressed from within outwards, and are very wide; but the *Bison*, *Bos Bison*, and the *Auroch*, *Bos Urus*, must be excepted, in which the ribs are narrow; in the *Solipeds*, as the Horse, they are also wide. But their greatest width is in the *Armadillos*, *Dasypus*, and *Ant-eaters*, *Myrmecophaga*, in which their breadth is so great that they overlap like tiles. In the Predatories and in the Gnawers they are generally of a more rounded form, inclining to an irregular square shape towards the spine, but compressed and widening towards their cartilaginous junction with the breast-bone. The whole Tribe of Monkeys are nearly approached in the form of their Ribs to Man. The first pair of Ribs is shortest and nearly fixed, being the base upon which the other Ribs are moved forwards, performing a swing-like motion upon the vertebres to which they are attached. Upon the front of this pair Meckel and Cuvier have noticed a little projecting process giving attachment to the scalene muscles in the *Guinea-Pig*, in the *Horse*, *Rhinoceros*, and others. The number of pairs of true Ribs, or those directly connected to the breast-bone, varies commonly from eight

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to eleven; but in the Cetaceans the number is much less; the *Dugong* has but three out of eighteen pairs; the *Manatee* only two of sixteen; and the *Pike-headed Whale* has only one true, but eleven pairs of false Ribs. The true Ribs are connected by their heads with articular surfaces on the sides of the bodies of the corresponding vertebres, two of which generally contribute to the formation of each articular surface, as already mentioned, excepting the first pair, which are received entirely on the first back vertebre. Their tubercles also furnish a second connexion, being articulated on the transverse process of the hinder of the two vertebres upon which the head of each Rib rests. The front pair of true Ribs is shortest, and thence they lengthen to the last, from which the remaining or false Ribs, so named from not being attached directly to the breast-bone, but consecutively with each other, shorten to the very last; a few of the hindmost of these being unconnected, and their lower ends having only muscular attachment, move very freely, and are called floating Ribs. The number of the false Ribs varies, but is greatest in those Beasts which have greatest freedom of motion in the chest. They are usually attached to the bodies only of the vertebres; but in the Cetaceans the greater number of the hinder false Ribs are attached only to the tips of the transverse processes, as in the *Porpesses*. In the Ruminators, on the contrary, all the Ribs, except the first pair, are connected with the bodies of two vertebres, and the greater number with the transverse processes also. But in the *Ornithorhynque* and *Echidna* the tubercles of the Ribs, although existing, are not attached to the transverse processes of the vertebres, the only connection with which is by their head.

The Breast-bone (o.) varies considerably in the number of its pieces, of which the *Unau* has most, viz., twelve, and the true *Whales* fewest, viz., one; but generally they range between four and eight or nine. The length of the bone does not, however, entirely depend on the number of pieces, which indeed are themselves of various lengths, but also upon the extent of cartilage by which they are connected; this is generally a thin plate of equal surface with the bones it connects, but sometimes a long narrow slip passes from one bone to the other, forming on each side a hollow, in which the ends of the osseous cartilages connecting the pair of ribs to the breast-bone are received, as in the *Sloths*. Neither are the several pieces always of equal size or shape. The most simple form occurs in those Beasts which are unprovided with collar-bones; in them the several pieces of the Breast-bone form a long triangular prism, with its base upwards towards the cavity of the Chest, the edges more or less rounded, and the upper margins slightly hollowed into as many concavities as there are pairs of cartilages of true ribs to be connected with them. Both ends of each piece are flat or slightly convex, but the first and last portions are exceptions; the former commonly projects before its connexion with the front pair of ribs, is rounded or pointed, and not unfrequently lengthened by a long projecting cartilage; the latter usually thins, expands, and has attached to it the so-called ensiform or sword-tip cartilage. The Spouting Cetaceans form an exception to this rule; for although they have not collar-bones, the Breast-bone is wide and thin, its first piece larger than the others, as in the *Porpesse* kind; but if only one, as in the *Whales*, it is broad, and in the *Pike-headed Whale* is of a horse-shoe shape, with the concavity backwards, and a large ridge projecting from the front of its under surface. In all those Beasts which are provided with collar-bones, the first piece of the Breast-bone is larger than the rest, and of size and shape best suited for the attachment of the muscles which bring the arms or fore limbs towards each other, or towards the middle of the Breast-bone. In the *Siamang, Hylobates syndactylus*, which belongs to the Monkey Family, the Breast-bone is of large size; its first piece is of great width, and wider in front towards the neck than behind, so that its side edges are oblique; the front angles are truncated obliquely forwards, and on each are two articular surfaces; the larger front one for the collar-bone, and another immediately behind it for the first rib; the second piece is oval, its shortest diameter transverse, the front end largely truncated to join the first bone, and the hind rounded end receives the corresponding extremity of the third piece, which is oblong, comparatively narrow, and tipped behind with a broad blunt cartilage. In the other members of this Family, the first piece of the Breast-bone is generally larger and squarer than the rest, which narrow, and are lengthened more and more as they approach the belly. In the *Brown Sajou, Cebus apella*, the first piece narrows behind the attachment of the first pair of ribs, and in the *Barbary Ape, Inuus sylvanus*, so much that it becomes T-shaped, the extremities of the cross-bar supporting the collar-bones and first pair of ribs. The same T-shaped form of this piece, but more distinctly developed, occurs in the Wing-handed Order, which are remarkably characterized by the large deep keel, well seen in our *Common Bat, Vespertilio murinus*, but is very considerable in the *Roussettes, Pteropus*, in which the hinder pieces are also keeled, though less deeply; thus do they present a remarkable analogy to Birds, as might be expected from their powers of flight.

In the *Great American Ant-eater* the first piece of the bone spreads out in front into a pair of large rounded wings, separated by a middle notch; it is contracted in the middle, and again spreads out behind to join the second piece, from which all the others, of square shape and gradually increasing in size towards the belly, have their under surface widened by a spreading straight lip. The *Middle Ant-eater* has not, however, this outspreading of the breast-bone pieces, though so stated by Cuvier; their first piece is large, but not so the rest. In the *Nine-banded Armadillo* the first piece resembles a Greek cross, with its head projecting, and keeled beneath. In the *Pangolins* the first piece is large, pentagonal, with its front projecting, and its last or sword-like piece of considerable length. The *Common Mole, Talpa Europæa* (Pl. IV., fig. 4.* o.), has the first piece of the Breast-bone of greater length than all the rest together; the junction of its hind end with the second piece is connected with the first pair of ribs, but the whole of it is entirely in front of the chest, moderately wide and thin, but furnished on its under surface with a deep crest (a.), which deepens rather beyond the middle of the bone, then suddenly shallowing expands laterally at its front extremity, and forms a pair of large articular surfaces for the collar-bones, which are separated by a slight vertical ridge. The *Ornithorhynque* (fig. 13. o.) is also remarkable for the projection of the first piece of the Breast-bone entirely in front of the chest, and its close resemblance to the corresponding part in the Saurous Order of Reptiles; its stem (a.), wide behind for junction with the base of the nearly triangular second



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piece, is contracted in the middle of its length, but in front stretches out on either side into a long slightly curved and tapering branch (b. b.), which joins the blade-bone; the remaining pieces are lengthy and slightly keeled beneath. In the *Echidna* the first piece has the same form as in the *Ornithorhynque*, but its proportions are more slender; the second and following pieces are transversely oblong square, and diminish posteriorly. In the Predacious Beasts the pieces of the Breast-bone are lengthy and of an oblong square shape, with their upper surface flat, the sides hollowed, and the under surface rounded. The first piece varies a little in shape and projection even in Beasts of the same kind: thus among the *Cats*, it is rounded in the *Tiger*, and triangular in the *Lion*. In the *Bears* the pieces are square and the front one rounded. And so also in the *Seals*. The Gnawers have also the Breast-bone consisting of many and lengthy pieces; and the Pouch-bearers are similarly circumstanced. In the Ruminators the whole Breast-bone is short, and its broad pieces widening towards the belly; their upper surface flat, and their under surface rounded transversely, as in *Oxen*. In the *Camel* the bone is very wide; and from the third piece, which increases in breadth and has a broad keel, the remaining hinder pieces become successively wider; the fourth forms a double keel, separated by an angular cleft, and each tipped with another round ended piece. In the *Cameleopard* the front piece of the Breast-bone is thin and shallow, but the others subsequently become very deep, and gradually widen to the hindmost, which gradually thins to its tip. In the Pachyderms the Breast-bone is generally flat, and widening from before backwards; its front pieces have sometimes a deep keel, which subsides as it passes backwards. But the keel is most distinct in the *Horse* kind.

4. Of the Locomotive Organs.

The whole Class of Beasts are furnished with both fore and hind limbs, upon which, with few exceptions, the trunk is supported, and by which its locomotive actions are performed. The Cetacean Order, however, forms an exception in being provided with fore limbs only, which are simply moving organs, the animals being sustained by the water in which they live.*

(A.) The *Fore Limbs*

Are variously formed and arranged in reference to other functions which they perform besides mere sustentation and locomotion. And indeed, as regards these offices, they differ; for in some kinds, as the *Jerboas*, *Dipus*, *Kanguroos*, *Macropus*, and other Beasts specially formed for leaping, the Fore Limbs are short and incapable of furnishing continuous support to the trunk; whilst, as to locomotion, the mode in which it is performed, whether in the various kinds of running, swimming, or flying, is indicated by the special construction of the Limbs for such purposes. The other or secondary functions of the Fore Limbs, comprising tearing, burrowing, and holding, also have important and decided influence on their construction.

The *Shoulder Girdle* consists either of a pair of blade-bones connected to the trunk simply by muscles, or of a pair of blade-bones and a pair of collar-bones; the latter of which connects the former to the trunk in addition to their muscular attachments. In those Fore Limbs which merely sustain and move the trunk without or with much speed, the Shoulder Girdle consists only of the blade-bones, upon which the trunk is suspended by muscles, as in the Pachyderms and Ruminators, in the Amphibious, Plantigrade, and most of the Digitigrade Predatories. In such, however, as, in addition to these functions, are capable of abducting and adducting these Limbs, of rotating them upon the shoulder-joint, and of compounding these and the ordinary movements forwards and backwards together, so as to perform the offices of flying, burrowing, or holding, in such the blade-bones are further connected with the trunk by means of the collar-bones, the special use of which is to prevent the shoulder-joints being dragged against the trunk, and interfering with the necessary freedom of motion in the other parts of these Limbs. This arrangement exists in the Wing-handed and Four-handed Orders, in the Insect-eating Predatories, in the Marsupials, and in most of the Gnawing and Toothless Orders. Some, however, of the Digitigrade Predatories, and of the Gnawing and Toothless Orders, have the blade-bones connected to the trunk by muscles only; but they have imperfect collar-bones unattached either to blade or breast bone, and suspended among the muscles. The *Hares* exhibit a remarkable difference from the other Gnawers in the entire absence of the collar-bones.

The Blade-bones (q.) are placed on the fore and lateral parts of the Chest in such Beasts as have either no collar-bones or only rudimental ones; but in those which are so provided they lie more upon the back than on the sides of the Chest. The general form of the bone is triangular, with the base or vertebral edge uppermost or nearest the spine, and its apex or humeral angle below thickened and expanded to form the socket for the head of the upper arm-bone; the front or cervical edge looks towards the neck, and the hind or abdominal edge towards the belly; the external surface is divided by a deep ridge called the spine, which stretches from or from near the base to the commencement of the outspreading of the humeral angle, and either ceases there or is lengthened into the acromial process which overhangs the shoulder-joint more or less. By the spine the exterior of the bone is divided into two unequal pits, in which large muscles are lodged. In those Beasts which have perfect collar-bones, and in a few others, a coracoid process projects from the front edge of the bone near the articular socket.

In the Spouting Cetaceans, as the *Porpesse* (fig. 24.), the Blade-bone is fan-shaped, with a very long and arched base, much longer than the vertical dimension of the bone from base to humeral angle, towards which both the front and hind edges of the bone converge; the outer surface has only a few slight muscular marks, and the spinous process consists of a broad and lengthy flat process (*p.*), which, commencing just behind the front edge of the bone, soon bends inwards and stretches forwards on the same plane as the bone; the slight space between its root and the front edge is the only indication of the supra-spinate pit, so that almost the entire exterior is the infra-spinate pit. The humeral angle expands, and has on its under surface the glenoid cavity (*s.*), concave from behind forwards. Upon the inside of its root projects forwards the broad coracoid process (*r.*), which curves a little outwards, and forms, with the spine, a wide pulley, over which the muscles, abducting and bringing forwards the fin, play. In the Herbivorous



* All the references to the figures of the Locomotive Organs belong to Skeleton of Beasts, Pl. IV.

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Cetaceans the Blade-bone is deeper from its base to the glenoid cavity; the former is shorter and more convex, the front edge is nearly vertical; the spine (ρ.) is nearly vertical to the external surface of the bone, with a little inclination forwards of its ridge: in the *Dugong* (fig. 1.) it commences about a third below the base, gradually deepening as it descends, but is always shallow; in the *Manatee* it rises more suddenly, is deeper, and part of its edge is thick; in the former it ceases suddenly, but in the latter overhangs the neck or lengthened root of the glenoid process, which curves a little backwards; in neither is there any coracoid process, like that of the *Porpesses*, the only analogue being, in the *Manatee*, a slight angular projection of the front edge just above the glenoid cavity.

In Ruminant Beasts the Blade-bone is a lengthy triangle with a very narrow straight base; the junction of the front and hind edges form a long neck, of which the termination is in the glenoid cavity, concave from behind forwards and downwards, above and before which the front edge terminates in an overhanging tubercle, which is called, but very improperly, the coracoid process (r.). The sharp spine commences sharply from the base, runs down to the neck, deepening as it proceeds, and vertical to the external surface of the bone; sometimes, as in the *Sheep* (fig. 2.), *Goats*, and *Oxen*, it terminates square, but at other times lengthens into a slender acromial process, which, in the *Antelopes* and *Deer*, overhangs the neck, and in the *Camel* kind descends as low as the plane of the glenoid cavity. The supra-spinate pit, in the *Camel*, *Deer*, and *Antelope* kinds, occupies about a third of the surface of the bone, but less in *Sheep* and *Cattle*; and in the *Cameleopard*, in which the spine subsides below into the front edge, it necessarily becomes still less.

In the Predatories the spine arises immediately from the base, and quickly becomes of considerable depth; its acromial process (ρ.*) descends below the plane of the glenoid cavity, and begins to have an expanded surface, which is increased by the stretching back, as in the *Dog* and *Cat* kind, of a little flat process, which in the *Lion* (fig. 9.) is deficient, but in the *Badger*, descends nearly to, and in the *Bears* quite to, the end of the acromion, with which it coalesces, forming in the latter a very broadly-expanded surface. In these animals the supra-spinate pit becomes of considerable size by the curving much forwards of the front edge, which juts out below so much that it has to revert to the neck almost at a right angle, thus rendering the whole bone nearly oblong square, with the neck descending from the hinder lower angle, as in the *Bears* and *Badgers*; and making the pit before and behind the spine of nearly equal size, with this difference, however, that the base of the supra-spinate pit is below, and that of the infra-spinate above. The so-called coracoid process, in this Order, subsides into the mere front end of the concave glenoid cavity.

In the Gnawers the pits of the Blade-bone are nearly of equal size, and sometimes indeed the supra-spinate is larger than the infra-spinate, as in the *Porcupine*, *Capybara*, *Rats* (fig.7.), and others, in which, however, the base is not very long but arched. In the *Jerboa*, a remarkable approximation to the form of the Blade-bone of the Monkeys and of Man is observable in the great length and straightness of the base, indicative of the great freedom of motion of the fore limbs. The widening or expansion backwards of the acromion is increased in those Gnawers which have not collar-bones, as in the *Guinea-Pig*, *Capybara*, &c., in which it does not descend below the glenoid plane, and in such the coracoid process is deficient. In the *Porcupine*, however, it is very considerably lengthened, and descends in a pointed form below the shoulder-joint. In those having collar-bones, the acromial process has its extremity either inclined at a right angle forwards, as in the *Squirrels* and *Rats*, or it is straight without any curve, as in the *Cape Mole-rat*, *Bathyergus*; but in this, and also in the *Coypu Rat*, a little movable bone occupies the place of the process just mentioned, and is interposed between the acromion and the collar-bone. In some instances, as in the *Marmot*, *Arctomys*, the acromion is enormously expanded behind, and overhangs more than the hind edge of the glenoid cavity.



Among the Toothless Beasts the form of the Blade-bone varies considerably; in the *Sloths* (fig. 5.) it is remarkable for the great length of its base, for the large development of its front edge, which renders the supra-spinate at least twice as large as the infra-spinate pit, and for the lengthening forwards and inwards of its slender coracoid process, which, connected by a bridge across the notch at its root to the front edge, converts the notch into a hole; its spine appears about the middle of the bone as a short triangle, of which the apex is lengthened forwards into a slender acromial process; the hind angle of the bone is truncated. In the *Pangolin* the supra-spinate pit is square, with its lower edge overhanging the front of the glenoid cavity, and much larger than the triangular infra-spinate pit; its spine is low and thick, but truncated, as in *Cattle*. In the *Ant-eaters* and *Armadillos* this bone is most remarkably developed; in the *Great Ant-eater* (fig. 6.) it forms a large fan, the upper margin of which is formed by the confluence of the arched base with the front edge so completely, that it is difficult, if not impossible, to determine their boundaries; the spine commences sharply a little below the base, and soon after its commencement sends back a triangular lip, deepens as it continues down almost close to the glenoid cavity, the neck being very short, and terminates in a long acromial process, which curves forwards, and descends before the front end of the glenoid cavity. In the *Middle Ant-eater* the base is straight, but the hind angle being truncated and rounded, it seems confluent with the posterior edge; its spine is deeper, but its form and that of its acromial process is very similar to the former species. On the infra-spinate pit a sharp ridge (χ.) descends from the base, and terminates by a little thickening just above the glenoid cavity in the *Great Ant-eater*, but in the *Middle* species this becomes a tall triangular spine; by the ridge in one, and spine in the other species, the hinder pit is divided into two distinct parts. The extension forwards of the rounded front edge before the glenoid cavity in the first species produces a notch, which is perfected into a large hole by its junction with the coracoid process expanded from the front of the neck in the same plane as the pit itself; but in the second species, in which the edge is straight, the hole is very small, and the distinction between the edge and the coracoid process not apparent. In the *Armadillos* the Blade-bone is of triangular form; the hind edge is very long, and the hind angle curving downwards renders it concave; in the *Nine-banded* species, this angle is separated from the common infra-spinate pit by a short ridge continued from the base into the hind edge; the same also occurs in the *Six-banded*, but the space separated is larger: the acromial process in both curves forward as in the *Ant-eaters*, but is more slender, and is connected with a collar-bone. In the

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*Six-banded* species there is a distinct and small, but beautifully curved, coracoid process; but in the *Nine-banded* it is scarcely developed.

Among the Marsupials the hind edge of the Blade-bone is straight, and its hind angle sharp; the base as far as the root of the spine being straight also, the infra-spinate pit is therefore of lengthened triangular form; the front edge projects much forwards, either straight or slightly arching, but drops suddenly upon the body above the lower end of the spine, rendering the infra-spinate pit squarish, and thus somewhat resembling the corresponding part in the Plantigrade Predatories, as the *Badger*; but it does not descend so low as in the latter animals. These circumstances are observable in the *Kanguroos*, *Kanguroo Rats*, *Bandicoots* and *Petaurists*, but most remarkably in the *Wombat*. The *Opossums* and the *Dasyures*, however, have the Blade-bone of more lengthy shape; in the former, both upper angles are rounded, giving the bone an oval form, and the pits are of nearly equal size; in the latter the supra-spinate pit is largest, and its front edge arched. In most of them the spine commences immediately from the base, deepens as it descends, and towards the lower end turns back a broadish lip, which runs into the broad acromion; but in the *Kanguroos* the spine commences below the base, is low and sharp above, and its acromial surface not wide. In this animal there is not any coracoid process, neither is there in the *Petaurist* nor *Bandicoot*; in the *Opossum* it is small, and only a little larger in the *Dasyures*, but in the *Wombat* it is well developed, and stretches very closely over the head of the arm-bone.

Among the Pachyderms, the *Swine* (fig. 3.), and those near allied to it, have the Blade-bone a lengthened triangle, with a short base, and the other edges converging to the neck, the front one being hollowed downwards; the spine is a short low triangle commencing below the base, it rises slightly, and again sinks into the neck; it generally sends back a short lip, but has not any coracoid process. The *Hippopotamus* resembles the *Swine*, but it has a strong short coracoid process. In the *Tapiir* and *Rhinoceros* the bone is very lengthy, and the base drops down rounded before and behind the origin of the spine, so that the upper part of the bone has a semi-oval figure; the hind edge in both animals is hollowed below towards the neck; in the former the flat coracoid process projects forwards, separated by a notch from the front edge, but in the latter it forms a large tubercle, inclining inwards, and in this animal a broad lip projects from the back edge of the spine. The *Elephant* is remarkable for the great length of the front edge of this bone, the shortness of its hind edge, and the obliquity of its base, so that the rounded superior front angle rises considerably above it, forming the apex of a triangle of which the base forms actually the hind edge; the spine is not very large, and its straight slender acromion does not reach below the middle of the neck, but just above the root of the latter a large flattened process projects back over the infra-spinate pit, and being connected by a concave edge to the acromion, seems as if that process had divided into a pair of forks. In the *Horse* the Blade-bone is long, and has a near resemblance to that of *Swine*, specially in the spine occupying only the middle part of the bone.

Among the Four-handed Beasts the Lemur Family have the Blade-bone long and triangular, with its hind edge longest, hind pit largest, a slender acromial and well formed coracoid process. In the Monkey Family the shape varies in some, as in the *Negro Monkey*, *Cercopithecus* (fig. 12.), the bone is long and the base short; in others, as the *Spider Monkey*, *Ateles*, it is shorter and its base more lengthened, but the base acquires very great length in the *Orangs* and *Chimpanzee*, and especially in the latter, in which it closely approaches the proportions of the human bone. The development of the spine also differs, and the expansion of its acromial process in many, among which the *Orangs* may be included, is continued slightly curved and narrow to its clavicular extremity; in others, as in the *Squirrel Monkey*, *Callithrix*, it only expands forwards; but in the *Chimpanzee* alone does it spread out in the triangular form, which is common to it and the human acromion. The coracoid process also varies in length, curve, and size, but it is best developed in the *Chimpanzee*.



All the members of the Wing-handed Order have the Blade-bone of great size; in the *Roussettes* its base is nearly three times as long as its front edge, and the hind edge is considerably expanded and rounded; this expansion of the hinder part of the bone is considerably increased in *Stenoderma*, and upon it a second crest rises in the infra-spinate pit, as in the *Ant-eaters*. The increase of the hind edge continues in the *Horse-shoe Bat*, *Rhinolophus*, and in the *Common Bat*, *Vespertilio* (fig. 10. q.*), and assumes an angular form, rendering the surface of the bone almost an oblong square. In the whole Order the acromion (*p.**) and coracoid process (*r.*) is largely developed.

The Blade-bone in the *Ornithorhynque* (fig. 23.) and in the *Echidna* is of very remarkable form, and in some striking particulars recall the form and connexion of that bone in the Lizard-like Reptiles. The position of the bone is very peculiar, inasmuch as that, instead of its flat surface resting upon the side of the chest, the entire bone is in front of that cavity, and its surfaces directed forwards and backwards, so that the bones jut out on each side of the bottom of the neck like the furniture with which horse-collars were formerly ornamented, the cervical edge (*g.*) being the outermost and straight, and the abdominal or inner one (*h.*), curved in consequence of the lengthening inwards of the large hinder angle, so that it nearly meets its fellow of the other bone upon the ridge of the spine. The lower end of the outer edge sends forward a flat horizontal process, which must be the acromial (*p.**), as it joins the collar-bone, as well also as with the horizontal branch of the breast-bone; and below this a lengthening downwards forms the neck, which terminates in a large deeply concave, articular surface (*o.*) for the upper arm-bone, facing upwards and backwards. From the inner and back part of this glenoid cavity stretches backwards and inwards a flat process, the coracoid (*r.*), which rests on the stem of the first and terminates by joining the second piece of the breast-bone; thus corresponding with the hind part of the coraco-clavicular bone of Lizards (see p. 313). From the front of the coracoid process a thin squarish piece curves outwards, and resting upon the upper surface of the branch of the first piece of the breast-bone perfects with it and the acromion the large circular hole which is here seen in the Lizards. In the *Echidna* the Blade-bone is very similar, but it is of less delicate proportions, and the loose piece in front of the coracoid process is of more triangular form.

In most striking contradistinction to the Blade-bones of

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the animals just mentioned is that of the *Moles*(fig.4.q.*), which is very long and disposed longitudinally on the chest, as in Birds, the base being the hind, and the head, with its articular surface forwards and outwards, being the front end, and but little narrower than the base; two small ridges mark its external surface, but can scarcely be called spines; a little lengthening backwards and downwards behind the glenoid cavity may be considered as the coracoid process. The bone is also remarkable for joining only with the arm-bone, and for not being connected, except by a long ligament, with the collar-bone. The *Golden Mole*, *Chrysochloris*, has, according to Cuvier, the next narrowest Blade-bone, but, compared with the former, it is of considerable width, and has always a very distinct spine and long acromion, by which it joins the collar-bone; and it has also the usual oblique position of this bone in Beasts. From the figure of the *Pyrenean Desman*, *Mygale*, given by Blainville, it would seem, however, that this kind occupies an intermediate position between those just mentioned.

The Collar-bone, or Clavicle (P.), is deficient in the Cetaceous, Ruminant, Pachydermatous, and Solipedous Orders; in some of the Predatories, Gnawers, and Toothless Beasts it is a mere rudiment, unconnected generally at either extremity with the breast or blade bone in most of the Predatory, and in some of the Gnawing and Toothless Orders; but it attains to perfection in most of the Toothless, Gnawing, and Marsupial Orders, in the Insect-eating Predatories, and is most developed in the Four-handed and Wing-handed Orders especially; its presence seeming to be always necessary where pronation and supination of the hand is to be performed. The general form of the perfect Collar-bone is irregularly cylindrical, with its outer extremity flattened from above downwards, and curving upwards and outwards to join the acromial process of the blade-bone, whilst its opposite extremity moves upon the front corner of the first piece of the breast-bone, and is always largest, as in the various kinds of *Bats* (in which it is sabre-shaped), where the freedom of motion at the shoulder-joint is greatest. In most of the *Monkeys* its shape resembles that of the human subject; but in the *Gibbons*, *Hylobates*, and the *Orangs*, and some others, it is simply a long bone, curved forwards or downwards, with little expansion of either extremity. In the *Ornithorhynque* and *Echidna* it is of very slender form, being merely a thin flat piece resting on the front of the branches of the first piece of the breast-bone, and joining with their extremities to the acromial process of each blade-bone. In the *Mole* (fig. 4*.) the Collar bones, small, short, square, deep, and thick, stand out on each side of the front of the first piece of the breast-bone, forming a very open angle forwards, and connected with it by a narrow vertical articular surface on their inner end, whilst on the outer is a very large oblong articular surface, concave from above downwards, for the upper arm-bone; on the under edge of the bone a short strong process descends.

The expressions *Fore Leg* or *Arm* are applied to the Fore Limbs of Beasts in reference to their employment, entirely or principally as organs of support, or as organs of holding more particularly, although also not unfrequently used as supports, and, with but few exceptions, as locomotive organs. Thus we speak of the Fore Leg of a *Horse*, or of a *Cat*, and the Arm of a *Monkey*; so again of the Wing of a Bat and the Fin of a *Porpesse*; but in either case the same parts of the skeleton are meant, although their special use is different, and in relation to which these Limbs are more or less free from the trunk, and have capability of moving upon the blade-bone in such peculiar direction as their habits require.



The Upper Arm-bone (s.) has nearly the same general position throughout the greater number of the Class of Beasts, resting on the front as well as hind limbs, viz. either on a parallel plane a little above the plane of the breast-bone, or on the same plane; consequently the head, or fore-part, is higher than the hinder end, or condyloid extremity, and the general position of the whole bone oblique; so that the elbow-joint is just free of the trunk. In the Wing-handed and Four-handed Orders, however, the Upper Arm has the same plane as the ridge of the back, and when in either Order, the trunk is rendered vertical by suspension, as in the *Bats*, or by elevation upon the heads of the thigh-bones, as in the *Monkeys*, these bones, when at rest, hang vertically from the blade-bone socket. The length of the Upper Arm-bone is much less than that of the fore-arm in Ruminating and Solipedous Beasts, as the *Sheep*, *Horse*, &c.; but in most other of the Class it is nearly of equal length; yet in none does it exceed the fore-arm, a peculiarity which specially belongs to Man. As to comparative length, the Upper Arm-bone is longest in the *Bats*, *Gibbons*, *Hylobates*, *Spider Monkeys*, *Ateles*, and *Sloths*; it is shortest and stoutest in the Monotremes and *Moles*. The shape of the bone has generally a cylindrical form, straight in the *Monkeys*, slightly arched forwards in the Gnawers, and many of the Edentate Beasts, and a little arched forwards above and backwards below in the Predatories and Ruminators. In all Beasts of which the motions of the Fore Limbs are restricted to progression, as in the Ruminant, Solipedous, and Pachydermatous Orders, the articular surface on the head of the Upper Arm-bone is broad, convex from behind forwards, and slightly so transversely, and facing more or less upwards, and is separated by a more or less distinct pit from the tubercles at the end of the shaft, of which the great external one is often outspread, so as to protect the dislocation of the arm inwards upon the blade-bone, as in the *Sheep* and *Ox*; but sometimes, as in the *Deer* and *Antelope* kinds, it rises up in front of the joint as a strong short process, which materially increases the power of the extending muscles of the limb attached to it. In the Predatory Order the articular surface rises higher, and is inclined over the inside of the shaft by the production of a sort of short neck, and the outer tubercle only acquires much size, and widens from behind forwards. In the Gnawers, and in Burrowing Beasts, as the *Ant-eaters*, the head becomes more distinct from the shaft, and has greater inclination upwards and inwards, depending on the outward direction given to the glenoid cavity by the interposition of the collar-bone between the breast and blade-bone. The convexity of the head and its distinction become greatest in the *Monkeys*; in the *Chimpanzee* it very nearly resembles that of the human subject; but in the *Orangs* it forms almost the very top of the shaft of the bone, with very little inclination inwards, and with its hemispherical surface directly upwards. The deltoid process stands much out from the upper part of the bone, and, being continuous with the great tubercle, renders the bone very wide at this part, whilst the lower end is much compressed immediately above the condyles, which

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spread out again in Ruminating and Solipedous Beasts. On the contrary, in most of the other Orders the bone spreads towards the condyles; in the *Ant-eaters*, indeed, an enormously broad process, pierced by a large hole, stretches inwards from just above the inner condyle, and renders the bone at this part of very great width. In the Ruminators and Pachyderms the lower end of the bone forms a wide pulley-like articular surface, which in front rests upon the spoke-bone, but is deeply cleft behind to lodge the ridged articular surface of the cubit, and has above it a deep pit, principally formed by the lengthening back of the condyles, into which the upper edge of the olecranon of the cubit sinks when the leg is projected forwards in violent progression; the condyles are in these animals nearly flat, and without any lateral extension. In the Predacious Beasts, a little projection of the inner condyle begins to appear, and the sharp edges which ascend from each condyle to the shaft considerably widen the lower end of the bone. In the Gnawers, and still more in the Wing-handed and Four-handed Beasts, the inner condyle becomes large and projecting inwards, and the articular surface wider, the cubit in the latter animals especially being shifted more inwards and the spoke-bone outwards, with a proper articular surface of its own; so that it can roll round, and perform pronation and supination more or less perfectly, at the same time that the breadth of the joint is materially increased. In proportion, however, as the condyles expand laterally their depth is diminished, but not sufficiently to destroy the pit for the olecranon, except in the *Ant-eaters* and *Sloths*. In some instances, indeed, as in the *Dog* kind, the pit becomes a perfect hole, through which the hind elevated edge of the articular cavity of the cubit passes. In some animals, specially the Predacious, a hole perforates obliquely the inner condyle for the passage of an artery. The Upper Arm-bone in the *Mole* (fig. 4*.) is of remarkable position and form: when at rest it rises upwards and outwards from the shoulder: so that its condyles are the highest part of the bone, which is short and wide at its extremities, but narrowed in the middle; the scapular half of the bone is squarish, and curved inwards, backwards, and upwards, forming a convex surface, which articulates with the collar-bone, and is bounded externally by a deep narrow head, to join the glenoid cavity of the blade-bone; the cubital half is nearly triangular, the angles of its base being formed by the condyles, which, especially the radial, lengthen into free flattened spaces, and have between them a pulley for the centre, and on the front of the outer a hemispherical articular surface for the spoke-bone. The *Golden Mole* (fig. 25.) has also this bone of peculiar form: it is generally less expanded than in the last-mentioned animal, but its inner or cubital condyle is lengthened into a very long thin process, which stretches downwards and forwards upon the fore-arm to the pisiform bone, but is perforated at its root by a hole, Blainville says, for the median nerve. In the *Ornithorhynque* and *Echidna* the bone is short: in the latter both condyles are much expanded, especially the outer, and much widen the surface. The head or scapular end of the bone has in its shape much resemblance to that of Birds, being lengthened from above downwards, and having an oval articular surface projecting inwards. In the *Ornithorhynque* the shape is nearly the same, but the parts are more sharp and delicate. In the Amphibious Predatories, as the *Seal*, &c., the Upper Arm-bone is short, the head widened from before backwards; a very strong ridge projecting from the upper and fore part rises into the little tubercle, the greater one being distinct and like a thick peg, and the lower end is widened transversely, and has thick condyles. In the *Dugong* and *Manatee* the form of the bone is very similar. In the Spouting Cetaceans, as the *Porpesse* (fig. 24.), the bone is short and oblong, but rather widest below transversely, and thickest above, where the semi-globular head faces backwards and upwards, and has in front a strong, thick, and slightly elevated tubercle; the lower end of the bone has two flat articular surfaces, separated by a middle ridge for the corresponding flat surface of the spoke-bone and cubit; but no motion, save a little yielding, is performed at their junction.

The *Fore Arm* of all Beasts, excepting the great Family of Monkeys, is in a constant state of pronation, either permanently, as in the Cetaceans, Ruminators, Solipeds, Pachyderms, and Wing-handed Orders, in which, being used only as part of the organs of support and motion, supination is not needed, and is, indeed, prevented by the close position of the two bones, the Spoke-bone (s) and Cubit (r.). The former of these bones is the largest and most important, and has its head or upper part very wide transversely, and receiving upon it the entire corresponding breadth of the articular surface on the lower end of the upper arm-bone, and with it forming the whole front of the joint; whilst the back of those surfaces is protected by the sigmoid cavity of the Cubit, which perfects the joint, and of which the olecranon process (φ.) is long, deep, and compressed. In others, however, though the Fore Arm is prone whilst used as an organ of progression, yet is it employed also for swimming, digging, or holding, as in the different Families of Predatories, in the Order of Gnawers, and in some of the Edentate and Marsupial Beasts, among which the Cubit acquires equal or greater size than the Spoke-bone, the head of which, now beginning to assume a cup-like form, thrusts more upon the outer condyle, which has a special semi-orbicular articular surface to receive it. The circumference of the head of the latter bone has also its band-like articular surface for lodgment in the lesser sigmoid cavity of the Cubit, more extended and more convex, and below it is a more or less strongly developed tubercle. Thence downwards the bone bows outwards to near its base, when it again approaches the base of the Cubit, which has its surface convex whilst that on the Spoke-bone is convex. All these provisions are necessary to enable the Fore Arm to perform supination, and in proportion to their increased size is the increase of supination and pronation, of which the perfection is found in the Four-handed Order.

In the Spouting Cetaceans (fig. 24.) the Fore Arm-bones are lengthy, flat, and prone; the Spoke-bone is the inner larger one, with a slightly sharp and curved edge, and the outer, with a concave edge and a little jutting olecranon process above, is the Cubit; they spread out transversely below for junction with the wrist-bones. In the Herbivorous Cetaceans both bones exist, and begin to assume a sort of cylindrical form; they are short, and the Spoke-bone being semi-prone on the Cubit, its edge is directed forwards; both bones enter into the elbow-joint, the Cubit behind and beneath, and the Spoke-bone before, forming a deep concavity, in which the articular surface of the upper arm plays. In the Solipeds, as the *Horse*, and in the Camel-like Family among the Ruminators, the Spoke-bone is the principal bone of the Fore Arm, and the imperfect Cubit soon unites with,

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Zoology.

and in fact becomes a process of it. The Spoke-bone is long, slight, arched from above downwards, rounded transversely in front, flat correspondingly behind, and expanded at both ends; upon the upper extremity is a pair of articular surfaces, concave from before backwards to receive the lower end of the upper arm-bone, which is prevented slipping backwards by the concavity in front of the Cubit, which rises up tall and thin as the olecranon process high above the joint, but thins away to nothing below, and is soon lost on the outer and back edge of the Spoke-bone, with which in the Camel Family it is completely blended; but in the *Horse* a groove and cleft mark the distinction between the two bones. The Spoke-bone alone by its wide extremity, on which are numerous articular surfaces, joins the uppermost row of the wrist-bones. In other Ruminators, *Cattle*, *Sheep* (fig. 2.), *Deer*, &c., the Spoke-bone is still the principal, but the Cubit exists as a distinct bone, and is continued thin and flat on the back and outer edges of the former to the wrist-joint, just above which it becomes trigonal, and sends down a little process which helps to form that joint.

In the Wing-handed Order (fig. 10.) the Fore Arm consists, as in the Solipeds, almost wholly of the Spoke-bone, extended at both ends. The Cubit also exists as a thin bone, widish and flat near the elbow, but tapering off to a point as it runs along the back of the former bone, about the middle of which it subsides; the olecranon process belonging to it is attached only by a ligament, and covers the back of the elbow as the knee-cap covers the knee.

In the Pachyderms the Cubit becomes much larger, and transmits part of the weight of the trunk to one or more of the wrist-bones, upon which it rests. In the *Elephant*, indeed, it is much larger than the Spoke-bone, which is the only example of such arrangement throughout the whole class. Its upper end receives nearly the whole articular surfaces of the upper arm-bone, with the outer of which the wide but thin heads of the Spoke-bone in front of the Cubit is joined; the lower trigonal end rests upon the outer two, and a small portion of the third wrist-bone of the first row, and upon the rest of the latter and the fourth bone, is received the Spoke-bone.

The Cubit continues increasing in size, and participating more in the formation of the elbow-joint in the Gnawers and Predatories; but the head of the Spoke-bone still continues wide, and occupies the principal part of the front of the joint in both those Gnawers, and the Insectivorous and Digitigrade Predatories which have not collar-bones; whilst, on the contrary, in such Gnawers as have collar-bones, as the *Squirrels*, *Jerboas*, and in the Plantigrade and Amphibious Predatories, which, though not having those bones, are required to perform supination and pronation in walking, climbing, and swimming, the Cubit forms the principal part of the elbow-joint, and the Spoke-bone has the cupped top of its rounded head articulating only with the correspondently developed semi-globular surface of the outer condyle, and its rounded margin rolling in the lesser sigmoid cavity of the Cubit. The Spoke-bone in these animals is also furnished with a tubercle a little below the head, which is developed in proportion to the extent of supination, and gives attachment to the great supinating as well as flexing muscle of the arm.

Among the Burrowing Edentate Beasts, as the *Anteaters* (fig. 6.), *Armadillos*, and the *Pangolins*, the Fore Arm-bones are wide and flattened, and the olecranon process of the Cubit long and compressed; in the *Anteaters* only, however, is the head of the Spoke-bone much rounded and cupped; consequently in them only is there much supination. In the others little more than common flexion and extension is performed on the elbow-joint.

Our *Common Mole* (fig. 4*.) has the Cubit largely compressed and developed above, and its olecranon process issuing above the joint, expands transversely, so that it assumes a T-shaped figure. The Cubit in the *Ornithorhynque* has its olecranon similar to that of the *Mole*. In the *Golden Mole* (fig. 25.) the olecranon is tall, somewhat trigonal, and a little curving over the sigmoid cavity; the resemblance to which of the same process in the *Echidna*, though less close, is very remarkable. On the contrary in the *Sloths* (fig. 5.) the olecranon is very short.

In the Family of Monkeys (fig. 12.) the head of the Spoke-bone nearly resembles that of Man, being completely round, and entirely articulating with the outer condyle; its tubercle is also much larger, and the base of the bone wider. The front lip of the great sigmoid cavity of the Cubit is also more projecting forwards; and the olecranon process, generally not very tall, is very thick, and somewhat triangular at its extremity.

The length of the Fore Arm, proportionate to that of the Upper Arm, varies in different Orders. In the Ruminators, Solipeds, and Wing-handed Order, it is considerably longer: in the Pachyderms and in the Digitigrade and Amphibious Predatories a little longer; in the other Orders of nearly equal length. The longest Fore Arms are those of the *Bats*, *Sloths*, and *Long-armed Apes*, *Hylobates*, and the shortest those of the *Moles*.

The *Wrist* (v.) of Beasts, or the *Knee* of Ruminators and Solipeds, as it is vulgarly called, is remarkably distinguished from that of Birds and Reptiles by the number of pieces, varying from five to eleven, of which it consists, and by the variety of their form. The ordinary number of Wrist-bones is eight, equally divided into an upper and lower row; in the former, three bones, the scaphoid, lunar, and cuneiform, are connected with the lower end of the fore arm, and the so-called pisiform bone, though in many instances completely unlike a pea, attached behind the latter bone; in the second row are the trapezial, trapezoid, great and unciform bones resting upon the palm-bones, and joining above with the first row.

Among the Spouting Cetaceans (fig. 24.) the Wrist-bones are very much flattened, and of oval or rounded form. Their connexion resembles, as well remarked by Cuvier, a pavement, and strongly recalls their disposition in the paddle or fore-foot of the Marine Turtles. In the *Dolphins* the first row consists of three, and the second of two bones; but in the *True Whales* there are four in the first and three in the second row. In the Grazing Cetaceans, the *Manatee* has six, equally divided in two rows, but the *Dugong* (fig. 1.) only four bones, arranged two in a row.

The Ruminators (fig. 2.) generally have four in the upper and two in the lower row, but the Camel-like Beasts have three bones in the second row, in which they resemble the Solipeds; in both Orders they are tall in proportion to their width.

In the Pachyderms the Wrist-bones are shorter but considerably expanded horizontally; this is especially



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remarkable in the *Elephant*, and recalls the shape of the wrist in the Land Tortoises.

In those animals which use the Fore Limbs for prehension or other similar motion, the Wrist-bones have their palmar surface generally much less wide than the dorsal, consequently an arch is formed in front, through which the flexing tendons of the fingers or toes pass.

The Wrist of the *Mole* (fig. 4.) has on its radial side a large sickle-shaped bone (*), which juts outwards from the palm, considerably increasing its breadth, and furnishing it with a sharp scoop-like edge, which materially assists it in burrowing. The *Golden Mole* (fig. 25.) has also a very remarkable process (*) springing from the outermost bone on the cubital side of the wrist, which runs up the Fore Arm like a third bone, and is connected with the long descending internal condyle of the Upper Arm-bone.

The Wrist-bones in the Wing-handed Order are seven, three in the first and four in the second row; of these one wide bone in the first row, the triple-bone of Meckel, who thinks it a combination of the scaphoid, lunar, and cuneiform bones, occupies the whole articular surface on the base of the spoke-bone, and has a remarkable similarity to the radiocarpal bone of Birds. Its lower end has two rounded heads, the outer of which partially supports the midhand bone of the thumb, and is separated on the dorsal surface by a deep pit, in which is received a little hooking process of the trapezial bone, tying the first and second row slightly together, from the inner larger head, which rests in a cup formed by the trapezial and trapezoid bones. More inward than this head, the front of the bone is widely hollow to receive the large protuberance of the second row, formed by the heads of the great and unciform bones; the former of which has a remarkable expansion interposed between the midhand bones of the thumb and little finger, and overhanging the roots of those of the other three fingers.

The Midhand (v.), or part immediately below the wrist, consists of less or more bones, according to the habits of the particular animal, and in vulgar language bears different names, although actually the same part. Thus the Leg of the *Horse*, of Ruminators, and of the Digitigrade Predatories, is the same as the middle of the Fin of the Amphibious Predatories, as the middle of the Wing of the Bats, the Instep of the Plantigrade Predatories, Gnawers, and Burrowing Beasts, and the Palm of the Hand in the Family of Monkeys.

Of those Beasts which use the Fore Limbs merely for support and progression, the Midhand is very lengthy, and consists either of one large bone, as in the Camel Family, also in *Oxen*, *Sheep* (fig. 27), and in some species of *Deer*, or of one large with a pair of smaller bones, one on either side entering into the composition of the wrist, as in the *Horse*, or with a pair of small bones at its base behind, as in the *Rein-Deer*, *Cervus tarandus*, *Roebuck*, *C. capreolus*, and the *Great Musk*, *Moschus moschiferus*, which in the *Fallow-Deer*, *Cervus dama*, are reduced to very small size; or of a large bone and a pair of slender ones of equal length with it, descending from the wrist or knee to the knuckle or Fetlock, as in the *Pigmy* and *Javan Musks*, *M. pygmæus* and *javanicus*.

The large middle bone is in all these animals called the Shank or Cannon-bone; its shape resembles a split cylinder with the convexity in front, and the flat surface behind. Its upper end, slightly expanded, has on the top several articular surfaces, more or less flat, and corresponding in number with the second row of the wrist-bones; the lower end, still more expanded and flattened from behind forwards, terminates below in the *Horse* in a large transverse semicylindrical articular surface, divided by a thick elevated ridge, which rests in the base of the single great pastern bone below. But in the Ruminators the lower end of the Cannon-bone is deeply cleft into two pulleys, which rest on the pair of great pastern bones. The pair of small bones, thick above and tapering to a point below, placed on the hind edge of the cannon in the *Horse*, are called Splint-bones, of which the outer is stoutest; they are connected by fibro-elastic tissue to the cannon, and their thick squarish base, rising above the base of that bone, uplift the greater part of the under surface of the wrist-bones from it, and consequently take off the shock to the limb when the foot is first brought to the ground, by themselves receiving the weight, and descending upon their elastic connexion with the cannon, till the wrist and cannon are brought into contact. The long Splint-bones at the back of the cannon in the *Pigmy* and *Javan Musks* (fig. 27. A. p.) have the same use; but their lower end has each an articular surface for the first piece of bone supporting the little hooflets at the back of the fetlock-joint, which are sustained in the *Rein-Deer* and *Great Musk* by the short basal splint-bones, and in the *Fallow-Deer* by bones still shorter, and in *Cattle* by bones connected with the sheath of the flexor tendons.

The Toe in the *Horse* consists of but one file of pieces, with some sessamoid bones. The uppermost of the three is the longest, and called the Great Pastern bone, flattened behind, and rounded transversely in front. It has both upper and lower end wider than the middle. The upper end, concave from behind forwards, and divided by a middle deeper groove, receives the lower end of the cannon, and with it forms the fetlock-joint. Its lower end is convex from before backwards, and slightly concave from side to side to join with the Lesser Pastern bone, of which the upper end is correspondingly concave, and, with its hinder lip much lengthened, forms the Pastern joint. The bone is nearly square, but wider than its height; its lower end is convex from behind forwards, and concave laterally to join the corresponding articular surface on the top of the coffin-bone, of which the front lip is much elevated, and with it forms the Coffin-joint. The Coffin-bone is of a half oval shape, with its short diameter transverse and posterior; its lower margin very thin, in consequence of the base or under surface being very concave, and splaying out considerably, both in front and sideways, from the transverse articular surface above. The Toe, consisting of the three bones just described, is not in the same vertical plane as the cannon, but projects forwards so as to form with it a very open angle; consequently the cannon-bone would seem to want support, as its head can be only partially received on the base of the great pastern. Such however is not the case, for the seeming deficiency is amply supplied, and also a most powerful suspending spring at the same time formed. To the hind margin of the base of the great pastern are attached a pair of trigonal bones, of which the upper concave surface receives all that part of the cannon not supported by the pastern: they are embraced by the tendons of the flexor muscle in their passage to the foot, and form a sort of cradle or couch suspended on grasshopper springs, in which the cannon

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rests, and the heavier the body is weighted, the more close is the application of these bones to each other, and the more is the joint strengthened. The passage of the flexor tendons from the back of the great pastern to the bottom of the coffin-bone, together with the widened lip of the little pastern, is sufficient to protect the ligaments of the joint from rupture. But at the back of the coffin-joint there is another trigonal bone of great width, called the Shuttle-bone, of which the principal use seems to be to throw the flexor tendon far back from the joint, and render its action more powerful, though it also adds to and perfects the system of springs, so far at least as the bones and ligaments are concerned.

In the Ruminators the Pastern and Coffin-bones are vertically cleft, so that there are two toes; hence are such called Cluven-footed or hoofed, or Bisulcous. A pair of hooflets are found at the back of the fetlock-joint in these animals, which sometimes are supported on a pair of small rudimental toes, with one, two, or more ranks, and either simply connected with the sheath of the flexor tendons, as in the *Sheep* and *Cattle*, or with the long splint-bones of the *Small Musks*, or with the short basal appendages of the cannon-bone, as in some *Deer*, and in the *Great Musk*.

The Family of Swine (fig. 3.) which connects the Pachyderms with the Ruminators, is distinguished by the four Midhand-bones being ranged on the same forward convex plane, and nearly of equal size; the middle two, however, being longest, but scarcely longer than the two toes which they support, of which the last joints are singly hoofed and point forwards, whilst the other shorter two, also hoofed, are directed backwards, and just touch the ground in consequence of the obliquity of the front toes. In the other Pachyderms, as in the *Tapiir*, *Hippopotamus*, and *Elephant*, the Midhand-bones are short, and except in the *Elephant* flattened, but in that animal are somewhat quadrangular. The ranks of the Toes are all very short, and the whole enclosed in a sort of bag, which is formed by the skin of the leg gathering around them into the thick, flat, almost shapeless sole of which the interior is divided into cavities, corresponding with the number of toes, and their position marked externally, by more or less broad blunt nails, which are ranged vertically above the margin of the sole. Such Beasts are called Multungular or Many-nailed.

In the Gnawers two principal forms of Paws or Forefeet may be observed. In the one the Midhand-bones are of equal length, or shorter than the toes, of which the extreme joints are furnished with broad nail-like claws,—such are the *Agoutis*, *Pacas*, and *Beavers*, and still more the *Sand-Mole*, *Bathyergus*, and *Zemni Spalax*, with their very long, slender, and curved nails leading on to the true Burrowers, and the *Capybara*, which by its all but hoofed nails reverts to the *Swine*. In the other form the Midhand is usually short, but the toes are furnished with sharp though not much curved claws; such are the *Marmot*, *Hamster*, *Rats*, *Porcupines*, &c. In the *Squirrels* and *Hares* the Midhand is very long, and the more talon-like claws lead to the Digitigrade Predatories. The number of perfect toes in this Order varies; the *Hares*, *Beavers*, *Porcupines*, and *Jerboas* have four toes, and a perfect though short thumb, not however opposable to the fingers: in the *Cavies*, *Marmots*, &c., the thumb has only two joints; but in the *Squirrels*, *Rats*, *Pacas*, and others, the thumb reduced to a single joint becomes a mere rudiment.

The *Common Mole* and the *Echidna* are furnished with broad shovel-like feet, and long broad and slightly curved nails, which admirably suit their burrowing habits. In the *Mole* (fig. 4*.) the Midhand-bones, and first two ranks of the finger-bones, are very short and squarish; but the terminating rank are very long, at least of equal length with the rest of the hand up to the spoke-bone, are covered entirely by their broad nails, and are the only part of the paw which projects beyond the skin. The breadth of the palm, which naturally rests upon its radial edge, is considerably increased by the sickle-shaped bone already mentioned. In the *Echidna* the Midhand-bones are squarish, the finger ranks very short and deep, but the last rank long, and entirely covered with very large, long, flattish nails. In the *Weasel-headed Armadillo* the paw is very wide; but the Midhand and finger-bones, especially those of the index and middle finger, lengthen, and become still longer in the *Nine-banded* species, which has only four toes, and consequently the paws narrower. But in both the thumb is very slender: the nail-joints in the *Weasel-headed Armadillo* are short, stout, and trigonal, with their radial side vertical, and the ulnar slanting; but in the *Nine-banded*, they are regularly rounded transversely, and are more slender and slightly curved. In the *Pangolins* the wrist-bones are very short and wide, and the Midhand-bones short and slender; the ranks of the middle three toes, especially of the central one, are deep and powerful; the nail-joints of all the toes are long and stout, and slightly curving, pointed, deeply cleft, more particularly over the upper surface. In the *Ant-eaters* the fore paws are of great size; the middle Midhand-bone and its corresponding finger are very large; but the first rank of the finger is very short; the last rank of the inner four toes are curved and lengthy, slightly rounded above in the *Great* but much compressed in the *Middle Ant-eater*, and from their base a collar is produced, which forms a sheath for the reception of the root of the corresponding claw; the outer toe has but a very short terminal joint. The *Golden Mole* (fig. 25.) has a very remarkable fore paw, which in the form, at least, of its toes, considerably resembles the *Ant-eaters*; the bulk of the paw consists of the large outer toe of two joints, and its supporting Midhand-bone, which represents the middle finger, the outer two being deficient; on the inside is the index finger of the same number of pieces, but slender; and upon the inside of its Midhand-bone is affixed at right angles that of the short thumb, which itself is directed at an angle towards the Index finger. For what purpose this curious arrangement is provided is not very clear.

The *Sloths* (fig. 5.) are very remarkable for the consolidation of the bases of the three Midhand-bones into one single piece, from the radial side of which projects a short compressed process, which is the rudiment of the thumb. The fingers each consist of but two pieces, which are long and compressed, especially the second rank; these are curved and covered with sharp claws, the roots of which are received in imperfect sheaths at the base of each bone enclosed.

Of the three Families into which the Predatories are divided, two are named in reference to the part of the paws on which they tread, and the third has the paws converted into fins; all however have five toes, of which the radial one or thumb is placed on the same plane with the rest, and not opposable. The Midhand-bones are long in the Digitigrade Family, as *Cats* (fig. 9.), *Dogs*, &c., but short in the Amphibious Family, as



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the *Seals* (fig. 8.), which latter however have the first rank of the finger or toe-bones longest, whilst in the Plantigrade Family, as the *Bears*, *Badgers*, &c., they are shortest and stoutest. The second rank of the finger-bones is shorter than the first, and upon that alone does the paw in Digitigrade Beasts touch the ground, whence their name, "walking on the toes." On the other hand, the Plantigrade Family are so named, because not only the whole under surface of all the finger-bones, but also that of the midhand or palm-bones, back to the second row of wrist-bones, is applied to the ground, either at rest or in progression. The curved terminal joints of the toes are all furnished with more or less curved and sharp claws, the roots of which are lodged in the sheath-like furrows at the base of the bones. The points of the claws or talons are in some instances, as in the *Cats*, kept sharp by not being permitted to touch the ground, except by voluntary effort of the animal, a thick knobby process being placed on the under surface of the bone, immediately in front of its articulation with the second bone, which on the toe touching the ground tilts up the points of the claw, and renders it nearly erect upon the second joint. In the *Seals* the second and third ranks of the finger-bones are short, straight, and slender, with the claw-joints but little curved.

The various kinds of Bats form the Wing-handed Order, in consequence of the great development of their hands, which being not only longer than the long fore arm, but even exceeding the entire length of the animal, serve as frameworks for the expansion and support of the extensions of the skin, which stretching from the sides of the body include also the fore and upper arm in front and the thigh and leg behind, and form Wings; of these all the part supported by the fingers can be shut up like a fan (of which the wrist represents the handle), against the ulnar side of the fore arm. Each Wing has its four very long Midhand-bones and corresponding fingers enclosed within the wing skin; but the thumb with which they are provided is free from it, and has a very short Midhand-bone jutting forward, and has at its extremity a long first and a short curved terminal claw rank, which project from it at a right angle, and, when the animal is on the ground, forms the principal resting part of the wing; it also sometimes forms a hook, by which the animal suspends itself on a wall or tree, as the *Roussettes*: in the *Phyllostomes* and *True Bats* the thumb (fig. 10. $\gamma$.) is less developed, and its claw straighter and smaller. The other Midhand-bones, excepting that of the index finger, are equally long, and their fingers of two ranks only, when at rest, are parallel, but on expansion radiate from the wrist; the index finger is shortest, and in the *Roussettes* consists of three ranks, of which the terminal one is clawed, and scarcely extends beyond the knuckle-joint of the middle finger; the two ranks of these are considerably longer than those of the fourth and fifth, and the terminal joint of all three taper to a point without nail or claw. In the *Phyllostomes* the thumb is clawed; the fore finger has a very long Midhand-bone and one tapering finger rank; the middle finger has four ranks and the last clawed, but the remaining two have only three ranks and the terminal one claw less. In *Noctilions* the thumb only is clawed, and so also in the *True Bats* and *Molossi*.

The Four-handed Order is, with few exceptions, furnished with four fingers and an opposable thumb, but less long than in Man; and it is also remarkable that in the Monkey Family, which so closely approaches the Human Race, the thumb should be shorter than in the Lemur Family, in the former of which it does not generally equal the length of the midhand. The Midhand-bones are longer than the first rank of the finger bones, which gradually diminish to their tip, and have the terminal rank small and flat generally; but in the *Flying Macauco* the second rank is longest, of greater length than the midhand-bones, and the terminal rank is compressed, and in shape somewhat like that of the *Cats*. The *Aye-aye*, *Cheiromys*, has the finger ranks of great length, and the terminal ones more lengthy and slender, though still compressed and curved; the middle finger is remarkably taper, and the long finger longer than it, is also considerably stouter. In the Monkey Family the Midhand-bones are longer than either of the finger ranks, which are not of very elegant form, are rounded transversely on their upper or dorsal surface and flat beneath; their terminal ranks short, flat, and covered with nails, generally flat, but in some few instances elevated longitudinally into a sort of ridge. The *Gibbons* or *Long-armed Apes* have the longest hands, and the *Mandrils* and *Baboons* the shortest in comparison with their bulk. Among the South American Monkeys, included in the Sub-family of *Sapajous*, the thumb diminishes in size, and, when the hand is covered with skin, seems entirely deficient; thus in the *Mikiri*, *Brachyteles macrotarsus*, it is scarcely discernible but for its little nail, which in the *Chamek* is entirely deficient: and the rounded end only of the single thumb-bone pressing against the skin indicates its existence; but in the *Coaitas*, *Ateles*, not even this indication exists. When, however, the skin is removed, a rudimental thumb of one or two joints, of which the terminal one is sometimes extremely small, like a little cap on the end of the first rank, is found close against the midhand-bone of the index, but, though furnished with muscles, it is incapable of more than a slightly yielding motion.

(B.) The *Hind Limbs*

In the Class of Beasts are specially adapted for locomotion, being (even in such as move on all fours) the levers by which the trunk is projected forwards; whilst the Fore Limbs are simply the props on which it rests during the adjustment of the Hind Limbs to such position as will enable them with greatest facility to project the body forwards, and the props upon which it is again received after projection has been effected. That the locomotive property specially belongs to the Hind Limbs is proved by observation of those Beasts which leap, either projecting the trunk forwards to be received on the short fore legs, as in the *Hares*, or in the still more striking examples of the *Jerboas* and *Kangurocs*, in which the body at all times erect upon the Hind Limbs is forcibly projected forwards by them, and again received upon them alone when the body returns to the ground. The Four-handed Order and the Hand-footed Family of Pouchbearers are remarkable for such arrangement of their Hind-Feet as renders them organs for holding or grasping similar to the hands.

The *Hip Girdle* of Beasts is, with few exceptions, distinguished from that of Birds by the ligamento-cartilaginous union of the hip-bones with the expanded transverse processes alone of the several pieces, one or more, of the vertebral column of which the rump-bone consists; and by the junction of the share-bones and

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sometimes of the haunch-bones also below, so that an irregular bony ring is formed, having on its sides the sockets enclosing the heads of the thigh-bones, and by means of which the weight of the trunk is transmitted to the Hind Limbs. Although the Hip-Girdle is generally named the Pelvis or basin, from its resemblance to a vessel of that kind, yet in the Slow-moving and Ant-eating Edentate Beasts only is anything like a true bony cavity formed. In most instances the Girdle can scarcely be described as more than a bony ring directed backwards and downwards, of which the front is more or less perfected above by the conjunction of the rump and hip bones, but is imperfect beneath; whilst, on the contrary, the back is more or less perfected beneath by the union of the share and haunch-bones, or of the share-bones alone, but imperfect above, though rendered somewhat more like a cavity by the continuance backwards of the root of the tail on the same plane as the spine, and therefore not unfrequently is the term "true pelvis" applied to it in opposition to "false pelvis," or the part of the Girdle which is in front, and has no series of bones continued through its imperfect part.

The most important parts of the Hip-Girdle are the Hip-sockets, which are situated on each side in the upper and fore part of the hind and under portion, at its junction with the upper and front portion, or in other words, at the confluence of the three pieces, hip, haunch, and share bones, of which, during immaturity, the Unnamed bones had been composed, though ultimately consolidated each set into a single large bone. Each socket consists of a hemispherical cup, the plane of which generally facing downwards and outwards, the upper lip lengthens out beyond the lower, and increases the surface by which it rests on the head of the thigh-bone. The edge of the cup is usually imperfect before and below, indicating the direction in which the thigh-bone is placed when the animal is at rest, and which in all Beasts is nearly at a right angle with the front plane of the Hip-Girdle. The Hip-socket is also distinguished from that of Birds in having a perfect bony bottom, except in the *Echidna* alone, which has the bottom of the cavity deficient in bone, and perfected by fibro-ligament. The junction of the share-bones with each other being always at an angle with the mesial plane of the body, their outer plane, as well as that of the haunch-bones which lengthen backwards from them, faces downwards and outwards, and occasionally also a little upwards and forwards, so that a line protruded either from their plane or from their junction beneath would be parallel to the axis of the spine, or impinge against it before the Girdle, which is a most remarkable distinction from that of Man, in which the plane of the front, or sides of the lower or hind portion of the Hip-Girdle, is such that a line continued forward from either of the sides would diverge largely from the spine, and could only be brought to impinge upon an imaginary lengthening of it, far behind the Hip-Girdle.

In the Cetaceans the Hip-Girdle is merely rudimental. In the *Porpesse* it consists of a pair of small oblong and slightly curved bones, connected by a pair of transverse pieces, and sustained only by the soft parts in the immediate neighbourhood of the vent, but entirely unconnected with the spine. On the contrary, in the *Rytina*, Steller describes on each side two bones, of which one oblong has its upper end connected by strong ligament with the thirty-fifth vertebre, and its lower end anchylosed with the second, which he considers the share-bone. In the *Indian Dugong*, from the transverse processes of the twenty-ninth vertebre descend a pair of bones to join by their lower and with a pair of narrower, smaller, and flat bones, which subsequently become consolidated into one. In the *Manatee* no such bones have been yet observed, but more probably have been overlooked and removed with the soft parts.

In all the other Orders the Hip-Girdle is fully developed on one general plan, but presents characteristic peculiarities in the different groups. To facilitate description it will be most convenient to consider it as consisting of an anterior and posterior portion, the hip-socket being interposed between the two, the former consisting of the rump and Hip bones, the latter of the Share and Haunch bones.

*a*. Hip-bone (G.) or Front portion of the Hip-Girdle.

In Ruminant Beasts the Hip-bone stretches forwards from the fore and upper part of the socket, with a long stout compressed neck like the flattened handle of a bat; its front spreads like a fan, of which the arc forms the crest, and the angles the upper and lower spinous processes, which are well defined; and as both are everted backwards, the lower much more than the upper, the outward back surface of the body or fan is concave, and the inner fore part convex; the upper spinous process rises free to the level of the vertebral spinous processes; but at its root on the inner surface is the irregular surface united by ligamento-cartilage to the transverse process or processes of so many rump vertebres as aid in forming the Hip-Girdle. In the *Ox* and *Sheep* (fig. 2.) kind the neck is stouter and shorter, the body more expanded, the lower spinous process is truncated and thick, and the crest inclined much outwards. In the Camel Family the neck of the bone is more lengthy, the inferior spine forms a thin sharp angle, and the crest is directed more forwards. In the *Goats* the neck is very long, the body of the bone very narrow, and the spinous process little developed. In the *Antelopes* the neck is very long, and the lower spinous process is lengthened much forwards. In the *Musks* the neck is deep and lengthy; the body is not wide, but the lower spinous process projecting much forwards causes the nearly straight crest to look upwards instead of forwards, and the upper spine being little developed, the front of the body has a squarish form.

This bone in the *Horse* very closely resembles the Ruminators; but its long neck soon spreads into a triangular body, the base of which forming the crest has its outer angle truncated more vertically than in the *Ox*, without any broad surface, and is much everted.

Great variety in the form of the Hip-bone is presented by the several Families of the Predatory Order. In the Digitigrades the remarkable characters of this bone are, the increased depth of its neck, which in the *Weasels* nearly equals that of its long narrow body; the shortness of the crest and the slight development of the spinous processes, which indeed in the *Weasels* and *Cats* (fig. 4.) may be considered deficient, the arching crest flowing directly into the upper and lower edges of the bone without interruption; the body of each bone faces towards its fellow, and is nearly parallel to the lateral plane of the vertebral column; so that this part of the Hip-Girdle is very narrow transversely in comparison with Ruminating Beasts. In the *Dogs* the

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deep neck soon terminates in an oblong square body, of which the crest is straight and the spinous processes angular; the upper or sacral edge terminating behind in an angle, whence it descends like a step to the upper edge of the neck, indicating the greater extent of junction with the rump-bone, and consequently the firmer connexion of the Hip-Girdle to the trunk and the greater motive power of the Hind Limbs: the front of the body is a little everted upwards, and therefore farther from the vertebral column than in the *Cats*, but it has still nearly the same disposition towards its fellow, although falling a little forwards and downwards. In the Plantigrade Family, as in the *Coati Mondis* (fig. 11.) and *Bears*, the neck is very short and thick; the principal part of the fan-shaped body faces forwards and downwards, and the lower spine is lengthened much downwards, outwards, and backwards, rendering the crest long and curved. In this Family also the neck not unfrequently assumes a trigonal shape in consequence of the extension of a sharp ridge backwards, from the lower spine towards or to the hip-joint; it is shortest in the *Bears* and *Racoons*, but in the *Otter*, *Coati Mondi*, and *Badger*, reaches the joint; in the former is blunt and rounded, but in the latter two thin and sharp. In the Insect-Eating Predatories, as the *Hedgehog* and *Tenrec*, and still more in the *Desman* and *Mole* (fig. 4.), this trigonal form of the neck exists, and is continued throughout the whole length of the body, so that the crest assumes a triangular shape. In all these animals the junction of this bone with the vertebral column is very long, especially in the *Moles*, and the front end stretches a little forwards and outwards. The Amphibious Family exhibit a very marked difference as to the form of the Hip-bone; in the *Walrus* it is very short, and the deep neck is nearly as deep as the body, which is very thick, and has its thick crest inclined a little outwards; but in the *Seals* (fig. 8.) the neck is much deeper, and the small thin body stretches directly outwards at a right angle from it on the same plane as the transverse process of the rump vertebre with which it joins; its surfaces consequently face directly forwards and backwards, the front one slightly convex, and the hind one deeply concave, by the overhanging of the thickened spinous processes.

The Gnawers generally resemble the *Hedgehog* in the transverse flattening of the neck of the Hip-bone, which in many instances, as in the *Marmot*, *Coypu Rat*, *Capybara*, &c., is also trigonal, with the ridge external, and the short square crest inclined outwards; but in others, as the *Rabbit* and *Squirrel*, the body is wider, the crest larger and a little everted, and the external surface divided into two by a lengthy ridge, which, running from the neck to the crest, faces backwards and upwards. In the *Porcupine* the ridge is so outstretched that the outer surface of the bone seems entirely occupied by the surface above it. In almost the whole Order, and specially in those Beasts which have the Hind Limbs long, the body of the Hip-bone projects free forwards and outwards in front of its junction with the rump-bone; this is well seen in the *Hares*, but still better in the *Jerboas*, which have the body of the bone spoon-shaped, but little larger than its neck, convex and facing inwards before, concave and facing outwards behind, with its spinous processes indistinct.

All the Leaping Pouchbearers, as the *Kanguroos* (fig. 19.), and *Kanguroo Rats*, resemble the *Jerboas* in the form of the Hip-bone, but have the lower or outer angle of the crest thick and square. The Hip-bone of the *Wombat* is very similar to that of the *Porcupine*, but its lower outer spinous process is more strongly hooked back. The *Opossums* have the bone not very unlike that of the *Hedgehog*. The *Dasyures* and *Thylacines* resemble pretty nearly the Digitigrade Predatories.

In the Edentate Order the Hip-bone presents several very different forms. In the *Ornithorhynque* and *Echidna* it is a short trigonal prism, with its base inwards, apex outwards, and its front triangular end projecting freely before the junction with the rump-bone. The *Pangolin* very closely resembles the *Echidna* in the prismatic form of its Hip-bone, but its proportions are more clumsy; it can scarcely be said to have any neck, for the body is continued back to the hind margin of the hip-socket, so that the sacro-ischial hole is completely posterior to that cavity. In the *Armadillos* the neck of the bone is depressed and long, the body trigonal, with its outer thin edge much developed, as is also the lower or outer spinous process, which curves much outwards, like that of the *Porcupine*, and has a broad thick extremity. In the *Ant-eaters* (fig. 6.) the short deep neck soon terminates in a large oblong square body, the hinder part of which rises up nearly vertically to the long straight upper edge, which throughout the greater part of its length joins the transverse processes of the rump-bone; the crest is rounded, and no spinous processes are developed, but the outer front end of the body inclines a little upwards, so that its front faces forwards and inwards; in the *Great Ant-eater* the body is shorter but wider; on the contrary, in the *Middle* species it is longer and narrower, the crest short and straight, its upper spinous process truncated, but the lower well developed and curving downwards. In the *Sloths* (fig. 5.) the neck of the bone is long, flat above, and having a sharp ridge beneath. It rises a little upwards and forwards, and expands into a thin oblong square body, which faces downwards and a very little inwards and forwards; the crest is straight; the upper spinous process truncated, and the lower rounded.

In the Thick-skinned Order the *Swine* (fig. 3.) has the neck long, the body small, with a sharp longitudinal ridge of the Hip-bone running into the short and rounded crest; the lower spinous process is everted. The *Rhinoceros* has great resemblance to the *Swine*; but its crest is longer, and the body has not any ridge. The *Tapir* is very like the *Ox* kind in the T-like form of the Hip-bone, in the truncated form of its spinous processes, especially of the broad outer one, and in the concavity of its crest. The *Hippopotamus* has the neck short, wide, and flattened horizontally; the body has an oblong squarish form widest transversely; the crest is straight from within outwards, but concave upwards and backwards, on account of the elevation of the square but thin spinous processes, the tops of which are nearly on the same level; the front of the body, nearly flat, looks downwards and a little forwards. In the *Elephant* the neck of the Hip-bone rises upwards and outwards, is flattish both behind and before, and soon expands into a large quadrant-shaped body, concave in front, and irregularly flat and convex behind; the upper spinous process being lengthened backwards into a thin angular termination and the lower one very thick and triangular, projecting forwards, downwards, and inwards; the very long crest between them has a wavy direction.

In the Wing-handed Order (fig. 10.) the Hip-bone has rather a long neck and narrow trigonal body;

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which, however, in the *Rhinoceros* and *Molossi* is wider, and the neck shorter.

Among the Four-handed Beasts in the Lemur Family the Hip-bone is of a lengthened triangular form, of which the short crest forms the base; it is longest and narrowest in the *Flying Macauco* and the *Lori;* but in the *Lemurs* it is shorter, wider in front, and the neck more distinct. In some of the Monkey Family the neck of the Hip-bone widens considerably, so that it is little narrower than the lengthy oblong body with its straight crest, as in the *Capuchin* and *Squirrel Monkeys*, *Cebus*, and others of their kind, in which also the body begins to be divided, by a longitudinal ridge from the inside of the neck, into two surfaces; the inner one facing inwards to its fellow and the outer facing forwards. The front one of the surfaces is largely developed in the *Mandrils*, *Howlers*, and others, and generally flat and of lengthened triangular form. In the *Orangs* and *Chimpanzee* the bone is shorter, especially in the former, than in other of this Family; the neck is wide in the *Orang*, but in the *Chimpanzee* narrower and trigonal; in both the front surface of the body is triangular, but in the *Chimpanzee* it is longest, and in the *Orangs* widest; in the latter it is flat, and in the former slightly convex, transversely in front and deeply concave behind; the crest is shortest and most convex in the *Chimpanzee*, but in both thin, except towards its upper or vertical spinous process, which thickens.

B. The Share (G*.) and Haunch-bone (G**.) or Hind portion of the Hip Girdle.

The general rule concerning this part of the Girdle is, that the bones unite beneath at the mesial line in a more or less lengthy seam or symphysis, but that they are unconnected with the vertebral column above. Exceptions, however, occur in the absence of junction of the bones with each other below, and in their connexion with the vertebres above. The principal differences in the form of this Hind portion, or True Basin as it is not unfrequently called, are the extent of junction of the two sides of the Hip-Girdle and the direction and extent of their planes, upon which depends the capacity of the actual cavity both longitudinally and transversely.

In Ruminating Beasts the transverse branch or body of the Share-bone, stretching directly inwards from the hip-joint, with a slight inclination downwards, joins its fellow, and forms the lower margin of the brim, which in this Order is an oblong square, with its angles rounded, and its greatest length vertical. From its inner end or pubic angle turns back the longitudinal branch, forming a long junction with its fellow at the pubic symphysis, which is parallel to the plane of the vertebral column above, and terminates in the lower branch of the Haunch-bone; the latter ascends outwards and backwards to join its upper long branch at a more or less distinct longitudinal ridge continued from the upper margin of the thyroid hole backwards. Above this ridge the upper branch, having upon it the tuberosity, stretches forward to the back of the hip-joint, and has its plane vertical, or with the upper edge inclined inwards. In consequence of the variation of direction in the superficial contour of the Share and Haunch bones, their external surface presents three planes; all that part formed by the Share-bone and in front of an imaginary line from the hip-joint to the pubic arch, faces downwards and a little outwards; between this line and the ridge of the upper branch of the Haunch-bone, the plane faces more outwards and also a little backwards, and above the ridge the plane is either vertical or upwards and outwards. The result of this arrangement is, that the true pelvis in Ruminators is wide and square below and in front, that it is angular and drawn inwards below and behind, and consequently narrower, and that above the whole aperture is diminished by the inward inclination of the upper parts of the Haunch-bones. These points are well seen in the *Sheep* (fig. 2.) and *Ox*, in which however the lower branch of the Haunch-bone is neither very tall nor very vertical; the back of the true pelvis therefore is not deep; but this branch is very much lengthened backwards and upwards, thereby increasing considerably the length of this cavity. In the *Deer* and *Antelope* kinds, and still more in the *Musks*, the hinder lower plane is taller and more vertical; therefore the arch of the outlet is narrow; the upper plane is more inclined inwards, so much so indeed in the latter kind, as to be nearly horizontal, and its hinder end lengthened considerably inwards, and in the *Meminna* and *Pigmy* species, unites with an elongation of the conjoined transverse processes of the upper tail-bones, producing a perfect hole, instead of the sacro-ischiatic notch. In the Camel Family, the body of the Share-bone drops more at its junction with its fellow, and the lower branch of the Haunch-bone scarcely inclines backwards; consequently the whole side faces outwards and downwards, and the arch of the outlet is wide, as is also its upper part; the upper branches of the Haunch-bone being nearly or completely vertical. In the *Cameleopard*, the body of the Share-bone is shortest of the whole Order, and consequently the brim is very narrow. The hind upper end of the Haunch-bone forms the tuberosity, which in the *Ox* kind is thick, of triangular shape, with its base inwards, and its apex jutting out. In the *Sheep* and *Deer* the tuberosity stands out laterally like a strong stud, which in the Camel Family is of considerable size and length, but on the contrary in the *Antelopes* and *Musks* very small, and in the *Cameleopard* entirely deficient; the tuberosity in this animal being merely a thickening of the slightly everted upper hind extremity of the bone.

In the Predatory Order the body of the Share-bone is thinner than in the Ruminators, and instead of stretching almost directly inwards towards its fellow, so that the pelvic margin should be transverse, and nearly on the same plane as a line drawn from the middle of one to that of the other hip-socket, it either is directed inwards and downwards to join its fellow at an angle, though the pelvic margin is still directly transverse, as in the *Cats* (fig. 9.) and *Dogs*, a little flattened stud showing its junction with the Hip-bone in front of the joint; or it stretches far backwards, as well as downwards and inwards, so that its union with its fellow is either just behind the hip-joint, as in the Plantigrade Tribe, the *Coati Mondi* (fig. 11.), *Badger*, &c., in which as well as in many other points, the *Otter* is allied to them; or it stretches back of great length, and with slight inclination downwards and inwards to join its fellow, and render the brim of the basin V-shaped, as in the *Seals;* or it runs back and inclines outwards, so that it does not touch its fellow, but the farther it is continued, more widely separated from it as in the *Moles*, consequently in them as in Birds the front of the basin is quite open. It is to be noted, however, that the little stud at the junction of the Hip and Share bones in the *Mole* is largely developed, though very thin, and nearly meeting its fellow, similates a true transverse brim, which it cer-

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tainly is not. In the *Hedgehog* the body of the Share-bone runs backwards and downwards, and sometimes near its tip suddenly turns inwards to join its fellow slightly; but at other times this inversion is not sufficiently long to bring the bones in apposition, and the brim is therefore imperfect; this may perhaps may be a sexual distinction. As regards the longitudinal branch of the Share-bone by which the pubic symphysis is effected, it may be taken as a rule which applies not only to this but to the other Orders, that it is lengthy and stout in proportion as the angle of the bone, or fore and under part of the brim of the basin approaches the transverse vertical plane of the hip-joint; thus both it and the symphysis are long in the Digitigrade and Plantigrade Tribes, as the *Cats, Dogs, Badgers*, and *Bearers*, or short in the Amphibious Tribe and Insectivorous Family, as the *Seals* and *Hedgehogs*, and also in the *Moles*. The width from before backwards of the lower or ascending branch of the Haunch-bone, which inclines much outwards, is in relative proportion to the extent of the pubic symphysis; if that be long the branch is wide, and its edge faces obliquely upwards and backwards, forming a more or less deep arch to the outlet. Such is the condition in the Digitigrade, and still more in the Plantigrade Beasts, as in the *Cats* and *Badgers*. On the contrary, in the Insectivorous Family the ascending branch rises almost vertically upwards with little eversion, and its hind edge inclines upwards and forwards, as in the *Hedgehog, Teledu, Mydaus*, and still more in the *Moles*. The tuberosity does not jut out distinctly as in the Ruminators, but is merely a thickening of the hind edge of the bone at the junction of its two branches, which is thickest, and inclines a little outwards in the *Dog* and *Cat* kind. In the Insectivorous Family, especially in the *Moles*, the tuberosity is not thicker than the other part of the bone, and in the *Seals* it is very similar. The upper or longitudinal branch of the Haunch-bone is generally of a trigonal form, its ridge being external, and continued from the tuberosity to the back of the hip-joint, and its base within facing upwards and inwards towards the vertical column. This ridge is remarkable, as indicating the boundary between the two planes only which the true basin presents in the Plantigrade and Digitigrade Families of this Order, of which the lower, facing downwards and outwards, is the larger, of irregular square form, and of relative size with the extent of the pubic symphysis and ascending branch; the upper is long and narrow, facing upwards and outwards. In the Insectivorous and Amphibious Families this upper branch is deep, compressed, and the upper face narrow and nearly horizontal, as in the *Hedgehog, Mole*, and *Seal* kinds. In the Plantigrade and Digitigrade Beasts, the ascending and the upper branches of the Haunch-bone are of nearly equal length, although the upper is by much the stoutest, as in the *Badgers, Bears, Cats*, and *Dogs*. In some of the Insect Eaters, the upper branch is rather longest, as in the *Hedgehog* and *Teledu*; but in others, as the *Moles*, it is of considerable length, nearly equalling that of the front branch of the Share-bone, and twice or three times so long as the ascending branch. The *Seals* have very close resemblance to the *Moles* in this respect. Upon the upper inner edge of the upper branch is a more or less elevated flattened stud, which is the ischial spine; it is low in the Plantigrade and Digitigrade Beasts, but tall and well marked in the Amphibious, as in the *Seals*. In the Insectivorous Family it is large, and may be easily mistaken in the *Mole*, and more particularly in the *Hedgehogs* and *Teledu*, for the tuberosity. The size of the thyroid hole varies considerably. In the Digitigrade Family it is oblong, with the angle rounded, as in the *Cats*. In the Plantigrade some have it nearly oval, with the short diameter from before backwards, as the *Badgers*; but others of a triangular form, with its longest side or base below and before, as in the *Coati Mondi*; or above, as in the *Otter*. Among the Insect-eaters the *Hedgehogs* resemble the *Coatis*, but the base is longer; in the *Moles* the hole is a very long oval from before backwards, as it is also in the *Seals* among the Amphibious Beasts.

In the Gnawers the body or descending branch of the Share-bone is long, with its front edge sharp and inclined a little inwards; it runs far downwards, inwards, and backwards to its fellow; the brim of the basin is therefore triangular, and faces much downwards and forwards. Its lower or longitudinal branch is generally of considerable length, and its junction with its fellow correspondently long, except in the *Mole Rats*, in which it is extremely short, and recalls the narrow connexion of these bones in the *Hedgehogs*. The lower branch of the Haunch-bones generally continues a little backwards and outwards, so as to form a short arch to the outlet before it curves up to meet its upper branch at the tuberosity; but in the *Mole Rats* it rises at once, so that one arch is absent; whilst on the contrary in the *Jerboas* it stretches far back, consequently the arch is deep. The lower branch generally widens as it ascends to the tuberosity, which, however, is not very large, but compressed and inclined a little inwards; in the *Mole Rats*, however, it is erect, and considerably so in the *Jerboas*, in which it is largely developed backwards. The horizontal branch which runs forwards to the hip-joint is moderately stout, and is sometimes furnished with an ischiatic spine. The true pelvis in this Order is of considerable extent from before backwards except in the *Mole Rats*, in which its greatest dimensions are vertical. This depends principally on the great length of both branches of the Share-bone; though the stretching backwards of the Haunch-bone also assists. The thyroid hole is also of correspondent size. Each lateral half of the pelvis has two planes; generally the fore and under one formed by the Share-bone face outwards and downwards, and the hinder upper produced by the Haunch-bone is vertical. In the *Jerboas* both face outwards and downwards, but the hind one is most vertical.

The general characters of the true basin in the Pouchbearers are its compression from above downwards, its width greater at the outlet than at the brim, the great length of its pubic symphysis, and the absence of any arch to the outlet. Exceptions to these points occur in the *Opossums*, which have a narrow triangular brim resembling the *Hedgehogs*, and a narrow pubic junction with a small arch; and in the *Wombats*, of which the junction is large and the arch very lengthy. But the most remarkable character in this Order is the existence of a pair of bones (a.), well seen in the *Kanguroo* (fig. 19*.), generally flat, lengthy, and curving towards each other, which are attached on the front of the Share-bones, and support the pouch of skin in which the young animals are perfected; whence the name of the Order, and the term Marsupial applied both to it and the bones themselves. In the *Thylacine*, however, they are merely rudimental, and

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about the size and shape of flattened peas. The body of the Share-bone, generally short and thin, runs backwards and much inwards to join its fellow, the connection with which is extensive in consequence of the length of its lower branch. The outlet has not any arch, the interspace between the lower ends of the vertical branches of the Haunch-bones being filled with bone; these branches are very wide, and as they rise into the tuberosities are much outstretched, rendering the outlet wider than the brim. The upper branch of the Haunch-bone and its tuberosity is stout and trigonal; in the *Wombat*, the tuberosity is enormously developed, and presents an irregular triangular surface, looking outwards and backwards.

With the single exception of the *Orycterope*, or *Cape Ant-eater*, the whole Toothless Order is characterized by the junction of the elevated tuberosity of the Haunch-bone with the transverse processes of one or more rump vertebres, and the consequent conversion of the sacro-ischiatic notch into a distinct hole. The true basin in this Order appears under two different forms; the one existing in the *Pangolins*, *Armadillos*, and *Sloths*, approaches the shape of the *Hedgehog*, and other Insect-eating Predatories; and the other seen in the *Ant-eaters*, *Myrmecophaga*, and more especially the *Cape Ant-eater*, which approximate to the Gnawers and the Monotremes. In the *Pangolins*, *Armadillos*, and *Sloths*, the body of the Share-bone stretches downwards, backwards, and inwards, till it meets and joins with the vertical branch of the Haunch-bone, and instead of the ordinary lower pubic branch being formed, the two united bones form a single process, lengthy and stout in the *Pangolins*, but slender in the *Sloths*, and shorter in the *Armadillos*, and in the *Nine-banded* species little thicker than a narrow tape, which runs inwards to the correspondent of the opposite side, forming the brim of the basin in front, and a very open arch to the outlet behind, in the *Sloths*, but in the *Pangolins* and *Armadillos* the arch is deficient, as the lower branch of the Haunch-bone is nearly vertical, though inclined much outwards. In the *Pangolins* the tuberosity of this bone is long, and its upper edge rises to join the broad transverse process of the last rump vertebre, and complete the sacro-ischiatic hole. In the *Armadillos* the tuberosity of the Haunch-bone is much developed, and has a remarkable process jutting horizontally outwards; nearly the whole length of its horizontal branch is connected with the wide transverse processes of many rump vertebres (fig. 16.).

In the *Sloths* the tuberosity is very thin, but rises high up to join the transverse processes above it. The whole true basin in these animals is very spacious, but very delicate. In them and in the *Armadillos* the thyroid hole is large, triangular, and below as well as behind the hip-socket; but in the *Pangolins* it is small, oval, and scarcely descends below that cavity. In the *Ant-eaters* and in the Monotrematous Family the Share-bones are joined by their lower branch, which in the *Ornithorhynque* is very long. The tuberosity of the Haunch-bone in the latter animal is lengthened backwards in a triangular shape, and so also that of the *Echidna*, but of less length, and in both the thyroid hole is almost directly below the hip-socket. Both these animals are furnished with marsupial bones, short and flat on the front of their Share-bones. In the *Ant-eaters* the vertical branch of the Haunch-bone rises up little outstretched from its fellow; so that the outlet of the basin is narrow; its upper branch inclines inwards, and its broad spine is attached to the under surface of the transverse processes of two rump vertebres, the tips of which overhang it, and thus perfect the sacro-ischiatic hole; the tuberosity is compressed, but thicker in the *Middle* than in the *Great Ant-eater*. In the *Orycterope* the upper branch of the Haunch-bone is slender and has no spine, nor does it join the rump-bone. The tuberosity, though thin, is very large and square; from its upper inner edge a slender process runs in towards the vertebral transverse processes, but does not join them, and from the outer edge juts out a flat triangular horizontal process.

In the Thick-skinned Order (fig. 3.) the true basin is wide and long, but shallow, owing to the horizontal lengthening of the front branch or body of the Share-bone, which runs directly inwards to its fellow; the lower branch is also very long, and its junction with the opposite bone very lengthy; the thyroid holes are therefore long and oval. The ascending branch of the Haunch-bone is short and directed much outwards, but its upper branch inclines inwards, is nearly straight, and devoid of spinous process. The tuberosity is either moderately developed, so that the arch of the outlet is short in the *Swine* and *Rhinoceros*, in which it is thick and depressed, or it is compressed, expanded, and rising above the edge of the upper branch, as in the *Tapir* and *Hippopotamus*. The true basin, compared with the size of the animal, is very small in the *Elephant*; the body of the Share-bone is horizontal, short, and flat, but its lower branch long, and consequently the symphysis long also; the ascending branch of the Haunch-bone rises directly upwards and outwards, without stretching back, consequently the outlet has no arch; it is short, and soon joins the upper branch at an angle, below which a thickening of the vertical branch is the only indication of tuberosity.

The Wing-handed Order (fig. 10.) have the Share and Haunch bones uniting at an angle without any lower branch to the former, nearly as in the *Hedgehog*, consequently each side of the true basin is of triangular form, including the triangular thyroid hole between the bones. Upon the front and only branch of the Share-bone is a projecting flattened spine (†.), variously developed in the different kinds of *Roussettes* and *Bats*; the branch itself descends backwards to the Haunch-bone, but in the *Roussettes* does not incline inwards to join its fellow, and consequently a large gap separates the two sides of the Hip-girdle. It is probable, however, that a bony band connects the two sides, as shown in one instance in a plate in Temminck's Monograph, and in another in a plate of Pander and D'Alton's. In these animals the upper branch of the Haunch-bone is the thickest part of the true pelvis, and approximates behind towards its fellow till terminating in the long compressed tuberosity which joins that of the opposite side, and thus forms an ischiatic instead of a pubic symphysis, and recalls the form of the pelvic junction in the Tailless Batrachian Reptiles. In the *True Bats* and in the *Horse-shoe Bats* this ischial junction does not exist; in the former a narrow long band connects the conjoined Share and Haunch-bones of each side; but whether this is a distinct bone, as in the *Roussettes*, or a lengthened process, as in the *Sloths*, is doubtful; in the latter the lower branch of the Share-bone is long, and the pubic symphysis distinct.

In the Four-banded Order the *Loris* (fig. 26.) are re-



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The *Hind Legs*, besides supporting the trunk when the animal stands at rest, are, in all Beasts excepting the Amphibious Predatories and the Wing-handed Order, the principal locomotive organs, projecting the trunk forward in a succession of springs, which in all the animal's paces are equally though less rapidly performed than in galloping. The kind of pace depends not merely on the quick repetition of the springs, but on the successive synchronous motions of both hind limbs and of both fore limbs as in galloping, or of successive synchronous motions of the hind and fore limb of opposite sides, as in cantering, or of the successive motion of the several limbs alternately before and behind of opposite sides, as in walking and trotting, of which the latter is simply a quick performance of the former. The mode in which the spring is performed and the body projected is readily illustrated by the simple action of leaping with a pole; in which case the one end of the long lever being placed on the ground far in front of the position of the person using it, the lever itself forming a more or less acute angle with the ground, the opposite end to which the party's weight is attached is impelled forward, and first rising, but subsequently descending, describes forward the arc of a circle, and deposits the performer in front of the fixed end of the lever at a similar distance to that which he had previously occupied behind it. In order that the Hind Limbs should perform this action, it is necessary that they should be much longer than the fore limbs; this is well exemplified in those Gnawers which move only by leaps, as all the *Hare* kind, and still more in the *Jerboas*, and in the Leaping Pouchbearers, as the *Kanguroo*, *Kanguroo Rats*, &c., in which the fore limbs have no participation in moving the trunk. With these exceptions, in which the greater length of the hind Limbs is very striking, the greater length of the Hind than that of the fore limbs is not at first apparent, but is readily proved to exist by bringing into a straight line the several members of the limb which, when at rest, mostly form angles with each other; thus the thigh-bone forms with the trunk one angle opening forwards, and with the shin-bone another, opening backwards, whilst the shin-bone, with the foot, forms a third angle, which opens forwards, and thus a pair of long levers are provided, folded to a certain extent indeed, to prevent the awkward position the trunk would have, were they at all times in the same plane, but still capable of being at any time and speedily placed in such condition. Their obliquity of position in reference to each other has also the further advantage of affording a constant spring, on which the trunk at all times rests, and by which jarring in its motions is prevented. Zoology.

The Thigh-bone (H.) of Beasts is distinguished from that of Birds generally in the greater length of its neck; in the articular surface received into the hip-socket being confined to the head; in the more distinct development of the trochanter, or great trochanter, and the appearance of a small tubercle or less trochanter, behind and below the junction of the neck with the shaft, and in many instances in the existence of a third trochanter, in shape of a flattened projection on the outside of the shaft far below the great trochanter; in the articular surfaces on the condyles being solely for the shin-bone, and its movable process the knee-cap, but entirely distinct from the splint-bone, which does not enter into the knee-joint. On the several proportions which these parts of the bone bear to each other, as also in respect to the length of its shaft, depend the shape and size which it assumes in the several Orders.

In the Ruminators (fig. 2.) generally the Thigh-bone is of equal length with the foot from the tuberosity of the heel-bone to the first rank of the toes, but shorter than the shin-bone. It is longer and most slender in the *Llama*, shortest and thickest in the *Giraffe*; but in the whole Order it is scarcely free from the trunk, and is commonly called the Haunch. The upper end of the bone is wide transversely, and has a somewhat T-headed shape; the flattened great trochanter jutting outwards and upwards nearly as much as the neck and head do inwards. The lower end of the bone is very deep from before backwards, in consequence of the perfect separation of the large articular surfaces for the knee-cap and shin-bone; of these the former is of an oblong square shape, with a deep chase in front for the knee-cap, and the inner edge more developed than the outer, though both are well marked.

In the Single-toed Beasts, as the *Horse*, the Thigh-bone, although nearly allied, is distinguished from that of the Ruminators by the greater breadth of its upper part depending on the outward extension of the third trochanter below the great one, which is also taller.

In the Carnivorous Predatories, as the *Cat* kind (fig. 9.), the Thigh and shin-bone are of equal length, a third longer than the foot, and disengaged from the trunk; the great trochanter is less outstanding and tall, but rises up more from the shaft of the bone than in the former Beasts. The lower end is more compressed; the edges of the chase for the knee-cap of equal height, and the chase itself seemingly continuous with the cleft between the

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condyles, and not separated from their articular surfaces. In the Plantigrade Family the Thigh-bone is round, but shorter than the shin-bone; and in the Insectivorous it is also shorter, but much flattened. In the Amphibious Family, as in the *Seals* (fig. 8.), the Thigh-bone is almost square, being short, very wide, and not more than a third of the length of the leg; its head is round and small upon a short neck; the trochanter, large and flat, rises above, but is separated from it by a concavity; the inner condyle is much longer than the outer, but its articular surface is smallest of the two; the pulley for the knee-cap is quite distinct from the condyles, and is wide and simple.

In the Gnawers the Thigh is shorter than the shin-bone; the great trochanter is tall, rising up from the top of the nearly straight shaft, and usually flattened from without inwards; but in the *Jerboas* it is flattened from behind forwards, and very tall; the neck stretches obliquely upwards and inwards. In some, as the *Squirrels*, *Marmots*, &c., the upper part of the shaft spreads outwards. The lower end of the bone increases in width; the chase for the knee-cap wider, and continued more irregular into the hollow between the condyles.

Among the Pouchbearers, the Leapers have the thigh generally as long as the foot, exclusive of the toes, as in the *Kanguroos* (fig. 19*.) and *Potooroos*; but in the *Kanguroo Rat* it is longer than the foot, including the toes; the neck of the thigh-bone is short, and the great trochanter long. The upper outspread and of the bone can scarcely be said to have a third trochanter, but rather a wing-like expansion, which in the *Wombat* is very considerable, and indeed the whole bone in this animal is very wide. In the *Dasyures* the great trochanter is short and outstanding, and the lesser much spread inward. The *Opossums* have a general resemblance to the Flesh-eating Predatories, and in both the latter kinds the Thigh-bone is not arched regularly forwards, but is concave above, and convex below, so that its form is somewhat like the italic *f* reversed. In the *Ornithorhynque*, the Thigh-bone is short, thin in the middle, but its ends wide; the trochanters form a pair of blunt horns, within which is the head supported on a neck which seems the continuation of the shaft of the bone; the lower wide end forms but a simple pulley, and the condyles are only separated behind. In the *Echidna*, the bone is stouter and wider than in the *Ornithorhynque*; its head is wider, larger, and supported on a shorter neck, and the trochanters are very short and regular.

In the Toothless Order some remarkable differences exist in the several Families, and even in the same family; thus the general proportions and shape of the Thigh-bone in the *Pangolins*, which is flattened and as long as the shin-bone, has much resemblance to that of the *Echidna*, but its broad upper end is principally formed by the expanded great trochanter from which juts obliquely upwards the short neck with the large head. The less trochanter is very small; but in the *Armadillos* the bone is longer than the shin-bone, has its shaft very flat, and like a reversed italic *f*; the great trochanter is very stout, tall, and rising high above the head of the thigh-bone; the lesser trochanter is large, but the third or outer one is of considerable size, much outstretched, and continued from the middle of the thigh to the outer angle. The *Orycterope* has its thigh-bone of very similar form, but proportionally shorter and stouter. In the *True Ant-eaters*, *Myrmecophaga* (fig. 6.), the trochanters are little developed; but from the greater one a sharp thin wide wing is continued down to the outer condyle, and thigh-bone not any trochanteric pit. In the *Sloths* the Thigh-bone is slender; it is flat above, and the head and trochanters closely resembling that of the *Echidna*.

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Among the Thick-skinned Beasts, the Thigh-bone of the *Elephant* is the longest and least strong, but of the *Hippopotamus* shortest and stoutest. In the *Elephant* the shaft of the bone is concave rather than convex in front; its great trochanter is little developed, and from it descends to the outer condyle a sharp thin ridge, which is nearly straight, whilst the inside of the bone from the head to the condyle is regularly curved. In the *Hippopotamus* the short cylindrical Thigh-bone has a tall stout great trochanter, with a large pit behind and within it; the head stretches inwards as the trochanter does outwards, so that the top of the bone seems T-headed. The *Swine* (fig. 3.) much resembles the *Hippopotamus*, but the shaft of the bone is longer. The great trochanter in the *Rhinoceros* is short and round, and the outer one is large, and situated on the middle of the shaft. In the *Tapiir* the great trochanter is very large and stout, and it has a wide square-shaped outer trochanter, which renders the top of the bone very wide. In all these animals, excepting the *Elephants*, the lower end of the thigh-bone is considerably thick from before backwards, depending on the large size of the pulley for the knee-cap, which is distinct from the condylar articular surfaces, as in the Ruminators.

In the Wing-hooded Order (fig. 10.) the Thigh-bone has its head on the top of the shaft, facing forwards instead of inwards; the short trochanters do not rise to the level of the head, but are disposed much as in the *Ornithorhynque*, and are farther remarkable in that the inner, or as it is commonly called the lesser trochanter, is the larger of the two: the shaft of the bone is nearly straight, but less long than the shin-bone; the condyles, although not large, are tolerably developed.

Throughout the whole of the Four-handed Order, both Lemurs and Monkeys (fig. 12.), the Thigh-bone is longer than the shin-bone, especially in the *Mandril* and *Gibbons*; and it is arched forward as in Man, except in the *Loris* and *Gibbons*, in which it is straight and slender. The absence of the sharp rough line, *linea aspera*, readily distinguishes the Thigh-bone of these animals from the human; but they approach it in the confluence of the knee-cap pulley with those on the condyles. A further distinction of the Monkey Family from Man is presented in the greater tallness and triangular shape of the great trochanter in the rudimental third trochanter, and in the greater width and flatness of the lower end of the bone, including the condyles, which is very decided even in the *Orang* and *Champanzee*.

The *Leg* consists of the Shin (*s*.) and Splint bone (*a*.), of which the latter is sometimes merely rudimental, as in the Ruminators, Solipeds, and many of the Wing-handed Order; or only partially developed, though of larger size, as in some of the Gnawers; or perfectly produced, as in the Predatory, Edentate, and other Orders.

In the Ruminators, as also in the Single-toed Order, the Shin-bone, often called the Thigh, is the longest member of the Hind Limb; at its upper end the shaft is trigonal, and the face between the front and side edge



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considerably hollowed, so that the edges, particularly the front one, are very sharp and prominent, but gradually subside towards the middle, and below this the bone has the appearance of a split flattened cylinder, of which the diameter is behind, and the arc in front. Upon the top of the bone the articular surfaces for the condyles of the thigh-bone are large but shallow, and the outer one overhangs often considerably the shaft of the bone, and, in some instances, a very short little dagger-like bone is attached beneath this overhanging part, and represents or rather is part of the rudimental Splint-bone. The lower end of the bone has a concave articular surface for the astragalus, which is protected on the inside by the short inner ankle, descending from the shaft of the bone below this articular surface. On the outside, the external ankle is a distinct bone of squarish shape, with a little spike-like process rising from its upper edge, which locks into a socket on the outside of the articular surface just mentioned; it represents the lower end of the Splint-bone, the body of which is in this Order deficient.

In the *Horse* and other Single-toed Beasts the Shin-bone has much the same form, but the outer ankle is a process of that bone; and the Splint-bone is merely a dagger-shaped bone, descending from beneath the overhanging head.

The Knee-cap, or Stiffle-bone, as it is called in the two preceding Orders, is of considerable size, protecting the front of the knee or Stiffle joint.

In the Predatories both Shin and Splint bone are present, the latter stretching from beneath the outer overhanging part of the head of the former to the outside of the ankle-joint; it is very slender, and either touches the Shin-bone merely by its two extremities, or is applied to the lower half of that bone. In the *Seals*, and other of the Amphibious Family, both bones, widely separated through the greater part of their length, are remarkably wide and flattened, the Shin-bone from before to behind, and the Splint-bone from within to without, and the outer ankle of the latter contributes very largely to the formation of the ankle-joint.

In some of the Gnawers, as the *Squirrels*, *Marmots*, *Pacas*, *Porcupines*, &c., the two bones are distinct throughout the whole length of the Leg, and in the latter the Splint-bone is pretty large; but in others, as the *Rats* and *Cape Mole Rat*, the Shin-bone arches much forward above and the Splint-bone laps against it about the middle, whence it becomes very thin and slender, and sometimes even deficient, till at the ankle its terminal process again appears. In the Leaping Gnawers, viz. the *Jerboas*, the Shin-bone is very long. The sharp front edge of the Shin-bone throughout almost the whole Order is very prominent and inclined outwards.

The Leg in the Pouchbearers consists of two bones; the inner ankle of the Shin-bone is little developed, and the Splint-bone has the remarkable peculiarity of articulating with the thigh-bone and entering into the composition of the knee-joint, as in Birds. In the Leapers, as the *Kanguroos* (fig. 19*.), *Potooroos*, and *Kanguroo Rats*, the leg is of great length, especially in the former kind, and the front edge of the Shin-bone strongly developed; the outer edge of its upper articular surface overhangs, consequently the Splint-bone is separated from its upper third by a gap; at this part it is rounded externally and sharp within, but the lower two-thirds are flat and closely applied along the outside of the Shin-bone. In the *Opossums*, *Couscous*, and *Wombats*, the Shin-bone is compressed laterally and arched, but in the *Dasyures* it resembles an Italic *f*. The top of the Splint-bone is compressed, but is very wide from before backwards, and, stretching behind the knee-joint, supports a little sesamoid bone. In all the animals just mentioned its connexion with the Shin-bone is so loose that an indifferent sort of rotatory motion is performed by them, which generates a kind of pronation and supination of the foot.



Among the Toothless Beasts the Leg is shorter than the thigh. In the *Armadillos* both ends of the Shin and Splint bones are consolidated, and the outer part of the head or upper end of the former is stretched out far from its shaft; so that a considerable space intervenes at the top of the leg between the two bones, which is further increased by the curving inwards of the former and outwards of the latter. The upper half of both bones is very wide from before backwards, and the front edge of the Shin-bone considerably everted; but the lower end at the ankle joint is very wide transversely. In the *Orycterope* the general disposition and character of the bones is nearly the same, but the space between them is less, and their lower ends are not consolidated. In the *Ant-eaters* and *Pangolins* the Leg-bones are comparatively slender, and, none of their parts being particularly developed, the Shin-bone has a trigonal and the Splint-bone a cylindrical form; their extremities are not very spacious. In the *Sloths* the Leg-bones are slender and much bowed in an opposite direction to each other, consequently the intervening space is wide; the Shin-bone is flattened laterally above, but from before to behind below. In the *Echidna* and *Ornithorhynque* the Splint-bone enters into the composition of the knee-joint, and has a remarkable process rising up from its upper end, like a long stud in the former above the middle of the thigh, tall and expanding like a fan in the latter.

The Thick-skinned Order, especially the *Rhinoceros* and *Hippopotamus*, have the Leg shorter than the thigh, and the Splint-bone slender, especially in the latter. In the *Swine* and *Tapir* the upper end of the bone is compressed and wide from before backwards, but not so in the other, in which it is only slightly enlarged to rest against the Shin-bone.

The length of the Leg varies in the Wing-handed Beasts. Sometimes it is longer than the thigh, as in the *Roussettes*, and in the *True Bats*, *Vespertilio*; sometimes of equal length, as in *Desmodus*, and at other times much shorter, as in the *Horse-shoe Bats*. In some, both bones are stout and well developed, closely approximated in *Desmodus*, but widely apart in the middle in the *Horse-shoe Bats*, in which the Splint-bone bows much outwards. In others, as in the *Roussettes*, *True Bats*, and *Noctilions*, the Splint-bone is only fully developed at the ankle joint; above it rises tapering to a point on the outside of the Shin-bone, but does not reach its head.

Among the Four-handed Order, including both Families, the Leg is shorter than the thigh. The Shin-bone arched forwards and generally bowed more or less inwards, is large and prismatic, the outer edge of its head, rather outspread, rests on the top of the slender and nearly straight Splint-bone.

The remaining part of the Hind extremity is anatomically called the Foot, including the instep, mid-foot, and toe-bones, which however differs in its form and disposition in many Orders, but has a correspondence

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with the character of the hand or terminal part of the fore-limb.

The Instep (L.) is that portion of the foot which is most nearly alike throughout the whole Class, its principal difference consisting in the number of bones, varying from five to seven, which it contains, and the form and disposition of its two largest pieces.

Five bones exist in all Ruminators except the Camel Family, which have six, and the *Giraffe* has but four. The Astragal or Knuckle-bone is of an oblong square shape, has a large pulley, convex from before backwards, with a deep middle depression by which it joins the lower end of the shin-bone at the ankle or hock-joint; its lower end has a convex pulley with a slight middle depression by which it rests in the naviculo-cuboid bone; at its back a smooth slightly convex surface rests it in the Heel-bone, which is deeply hollowed in front to receive it, and has also a tall thick lip on the outer side to prevent the knuckle-bone slipping off as it plays upon the heel and naviculo-cuboid bones, although the principal motion is above, between it and shin-bone. An articular surface at the fore and outer end of that bone joins it also with the naviculo-cuboid. But the most remarkable and important part of the Heel-bone is its tuberosity, the Hock, of vulgar language, which projects back much compressed, and hollowed on the inside for the passage of tendons and vessels. Upon the length of this process, in comparison with the length of the bone, depends the power of the lever which it becomes to the foot, and the force with which the body is thrown forwards from the hock. The Naviculo-cuboid bone stretches across the instep from side to side; its principal inner and upper part receives the knuckle-bone, and the outer and upper joins the heel-bone; below, it joins the cannon-bone on the outside, but a thin broad quadrant-shaped Cuneiform bone in front, and a much smaller square Cuneiform behind it, separates the two bones on the inside. In the *Camel* that portion of the Naviculo-cuboid above the Cuneiform is a distinct piece, and is called the Navicular, the name cuboid being applied only to the outer piece. In the *Giraffe* the Naviculo-cuboid is as in the Ruminators generally, but the two Cuneiform bones are consolidated into a single piece.

In the Single-toed Order the Knuckle-bone is shorter; its upper end has an oblique pulley deeply grooved for junction with the shin-bone, but the lower end is flat, to join with the flat Navicular bone; so that between it and the Knuckle-bone there is merely a gliding but no play as in the Ruminators, nor is there any lip on the outside of the sockets of the Heel-bone to prevent its displacement outwards. The tuberosity of the latter bone is shorter but deeper and stronger. The Navicular bone, thin, wide and flat, joins below in front with the nearly equally thin, wide, and flat great Cuneiform bone, which below rests on the head of the cannon-bone, and behind with the little Cuneiform, which is connected with the main spring-bone, as is the principal part of the Cuboid on the outside with the outer spring-bone, whilst its hind end joins the Heel-bone.

All the Families of the Predatory Order (figs. 8, 9, 11, 24, 25.) have seven bones to the Instep, there being three Cuneiform instead of two. The Astragal has its lower end inclined inwards, whilst that of the Heel-bone looks a little outwards, in consequence of which the Navicular, Cuneiform, and Cuboid bones are more outspread transversely, and the Instep rendered wider, as requisite to sustain the greater number of the foot-bones, of which there are four large and a little rudimental one in the Digitigrade, but five in the Plantigrade Beasts. The Astragal is well locked in at the ankle-joint, and specially on the outside, by the lower end of the splint-bone. In the Amphibious Family the tuberosity of the Heel-bone is short in the *Morse*, but in the *Seals* (fig. 8.) it is entirely deficient, and the bone itself is shorter and smaller than the Astragal, which is of very considerable size, and has a long process stretching from its back part, which seems to replace the tuberosity of the Heel-bone.

In the Gnawers the tuberosity of the Heel-bone is generally long. In those which have five toes, as the *Squirrels*, *Marmots*, *Rats*, &c., the Navicular bone is divided into two pieces, one below and the other on the inner side of the Astragal, the latter connected below with the inner, and the former with the middle and outer Cuneiform bones; it has also sometimes a tubercle, and sometimes a little styloid process stretching beneath the cuneiform bones. In the *Beaver* a flat supernumerary bone runs along the Instep, as also in many other Gnawers, but of small size. In such as have only four toes, as the *Jerboas*, as well also as in the *Hare* kind, the process on the under surface of the Navicular is very long and wide, and in the latter continued beneath the basis of the inner mid-foot bone. In the three-toed Gnawers, as the *Guinea Pig*, *Cavies*, &c., the navicular bone is very thin, and has connected with it a large Cuneiform, which joins the middle mid-foot bone, and a small one for the inner bone and rudiment of the thumb.

Among the Pouchbearers the tuberosity of the Heel-bone is of considerable length in the *Kanguroo*, *Kanguroo Rats*, and *Potooroos*, and the bone is further remarkable for a concavity on its outer and fore part, in which the lower end of the splint-bone is received. In those Beasts the Cuboid is the largest bone of the Instep next to the Heel-bone, but the Navicular and Cuneiform are very small.

In the Toothless Order the tuberosity of the Heel-bone is, in the *Armadillos*, of great length, deep, and compressed, and the Astragal of great width. In the *Orycterope* and *Pangolins*, the tuberosity, though large, is less long, and in the *Ant-eaters* is much shorter. The *Sloths* are remarkable for the great length, thinness, depth, and curving downwards of the tuberosity of the Heel-bone, the peculiar form of the head of the Astragal, the inside of which is convex and overlapped by the inner ankle of the shin-bone, whilst the outside is a deep conical cavity, receiving the cone-like lower end of the splint-bone, upon which the Instep turns round, as upon a centre. In the Monotrematous Family the Astragal is considerably larger than the Heel-bone, of which the tuberosity, instead of being directed backwards, descends to the ground, and forms the outer pier of a bridge, of which the inner is formed by the bone connecting the Astragal to the Spur-bone at the back of the foot, and which, in the *Ornithorhynque*, is of very large size, flat, broad, and rising up above the base of the shin-bone.

Among the Thick-skinned Beasts the *Elephants* are remarkable for the shortness, flatness, and width of their Instep-bones, and the depth and shortness of the tuberosity of the Heel-bone. The general number of bones is six.

In the Wing-handed Order the *Roussettes* have the tuberosity of the Heel-bone curved downwards and in-

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Zoology. wards into the sole: but in the greater number of the various kinds of *Bats* (fig. 10.), a long and movable styloid process (φ.) is attached upon it, which is enclosed within the inter-femoral portion of the Wing membrane.

In both Families of the Four-handed Order, excepting the *Orangs* and *Chimpanzees*, the most striking characters are the great length of the Instep, principally dependent on the length of the Navicular and outer Cuneiform bone; the shortness, width, and upward curving of the Heel-bone, and the large development and inward direction of the front articular surface of the inner Cuneiform bone upon which the midfoot-bone of the thumb plays. The articular surface on the Astragal for the outer ankle is very upright, and for the inner very oblique, which throws the foot on the outer edge in walking, though well adapted for climbing trees. In the *Orangs* and *Chimpanzees* the whole Instep is very wide, but very short; the tuberosity of the Heel-bone is compressed, and bent downwards as in Man; the Navicular bone is short but very wide, and has an enormously large tubercle on its inner under part, which greatly increases its breadth.

The Midfoot (M.) consists of more or less bones in the several Orders. In the Ruminators there is but a single bone, which, as in the Fore Limb, is divided below by a cleft into two articular surfaces for the two toes. An exception to this rule occurs, however, in the *Musks*, which have on the back of the Cannon-bone a pair of Splint-bones (fig. 27. B. σ.) similar to those on the foreleg. In the Solipeds, besides the Cannon-bone, a pair of Spring-bones are connected to it by elastic ligament on each of its hind edges; their bases rise above the base of the Cannon; the inner joins with the little cuneiform, and the outer with the cuboid bone. As they descend they taper each to a point, and terminate about a third the length of the bone above the fetlock. Among the Predatories, the Digitigrade Family, as the *Cat* and *Dog* kinds, have four bones, the outer two connected with the cuboid, the inner two with the outer two cuneiform; a rudimental thumb appears as a short stud attached upon the inner cuneiform. In the Plantigrade Family, as the *Bears, Badgers*, &c., there are five bones, the inner three attached to the cuneiform, the fourth to the outer cuneiform and cuboid, and the fifth to the latter bone alone. In the Amphibious Family, the *Seals* are remarkable for having the middle bone shortest of the five, and the outer one of nearly equal length with the inner; and they are all so attached to the instep bones that they may radiate and render the front of the fin considerably wider than its hind part. Among the Gnawers some have five, others four and a rudiment, and some only three and one rudimentary Midfoot-bones, and they vary considerably in length and width, being proportionally slender as they are long, and wide as they are short. But in this Order there are two remarkable leapers, of which the one, *Forster's Jerboa, Helamys*, has four bones of very considerable length, of which the outermost is very slender, and a small rudiment of a thumb; the other is the *True Jerboa, Dipus*, which has but a single long cannon-bone; its lower end spreads and forms two large articular surfaces for the two large toes, and between them is a smaller one for the slender long middle toe. Among the Pouchbearers some have five Midfoot-bones, as the *Wombats* and *Myrmecobius*; some have the inner one supporting the thumb freely movable on its cuneiform bone, and thus converting the first into a kind of hand, whence such are called Pedimanous, as the *Opossums* and *Dasyures*. But others have only four Midfoot-bones, as the *Kanguroos, Kanguroo Rats, Potooroos*, and *Bandicoots*; in these the inner two bones are very delicate, slender, and long, and applied closely against the inside of the third, which is of great length and corresponding bulk, nearly flat above and rounded beneath, with a large simple pulley on its front end; the outer bone is also large, but less than the former, and slightly arched; it is compressed, and somewhat trigonal, with the sharp edge uppermost. Among the Toothless Order there are usually five bones, of which the inner and outer are shorter and smaller than the others; sometimes they are wide and flat above, as in the *Armadillos*, sometimes compressed, as in the *True Ant-eaters*; in the *Pangolins* the bones are short, but in the *Orycterope* long; the latter however are well proportioned. The *Sloths* (fig. 5.) are remarkable for their resemblance to the *Penguins* in the consolidation together of the hind end of their three perfect, and of their inner and outer rudimentary Midfoot-bones with the cuneiform and cuboid bones, so that they appear as a transverse bony band with three projecting processes supporting many toes. In the *Echidna* and *Ornithorhynque*, these bones are short, thickish, and the inner one very short in the former, and slender, and the middle three shortest in the latter in which the foot is webbed. Among the Thick-skins, the *Rhinoceros* and *Tapiir* have three, and the *Hippopotamus* four bones short and wide; the *Swine* have also four, of which the middle two are large and wide; the inner and outer are smaller, shorter, and the toes attached to them do not reach the ground. In the *Elephant* these bones are short and nearly square. In the Wing-handed Beasts the bones are all short and slender, but spread out in a somewhat radiated form from the instep. The Lemurs and Monkeys derive their name Four-handed in consequence of the mobility of the thumb or inner toe, of which the Midfoot-bone is thicker and stouter than either of the others. There is little natural difference as regards the Midfoot-bone in these animals, except as to their length; but it may be noted that they are generally more or less arched, and that in the *Orangs* they are larger than in the *Chimpanzee*. Zoology.

As regards the Toes, those of the Hind feet usually resemble those of the front feet; but a few exceptions exist; as in the clawed toes of the hind feet of the *Moles, Roussettes*, and *Bats*, and the hoofed outer two toes of the *Kanguroos*, which have the inner smaller ones sharply clawed.

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# INDEX TO THE ZOOLOGY.

## Section I.

*General view of the Animal Kingdom, and of the circumstances distinguishing it from the Vegetable Kingdom.*



### Organic or Vegetative Functions.



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### Section II.

*Description and Comparison of the Organs in the several Classes of Animals, or*

#### Zootomy and Comparative Anatomy.





#### Of the Passive Motive Organs, or Skeleton of the Vertebrate Series of Animals.

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# ZOOLOGY.

## THE PLATES

SYSTEMATICALLY ARRANGED,

OF WHICH THE GENERAL DESCRIPTIONS ARE CONTAINED IN THE MISCELLANEOUS DIVISION OF THIS WORK.

### A. VERTEBRATE SERIES.

CLASS. BEASTS—*Mammalia.*

#### I. ORDER. Four-handed—*Quadrumana.*

*Family.* Monkeys—*Simiaida.*

PLATE 1.

| | |
|---|---|
| Simia satyrus | Orang-outang |
| Semnopithecus maurus | Lotong |
| —— nasicus (a) vel larvatus | Kahau or Proboscis Monkey |
| Cynocephalus vel Papio } mormon | Mandril or Great Baboon. |

PLATE 2.

| | |
|---|---|
| Cercopithecus ruber | Patas, Royal or Red Monkey |
| Cebus fatuellus | Mico or Horned Monkey |
| —— sciureus | Saimiri or Squirrel Monkey |
| —— paniscus vel Ateles paniscus | Coäita or Four-fingered Monkey |
| Hapale communis | Ouistiti or Striated Monkey |
| —— rosalia | Marikina or Silky Monkey. |

*Family.* Lemurs—*Lemurida.*

PLATE 3. (b)

| | |
|---|---|
| Lemur catta | Ring-tailed Maucauco |
| Lichanotus Madagascariensis | Short-tailed Indri |
| Stenops tardigradus | Bengal Lori |
| Otolicnus Senegalensis | Senegal Galago |
| Tarsius Daubentonii | Daubenton's Tarsier |
| —— Bancanus | Young of the former, according to Temminck. |

#### II. ORDER. Wing-handed—*Cheiroptera.* (c)

*Family.* Roussettes or Fruit-eaters—*Fructivora.*

PLATE 4.

| | |
|---|---|
| Pteropus Javanicus | Kalong or Java Roussette. |

*Family.* Leafless-nosed Bats.

| | |
|---|---|
| Molossus velox. | |

*Family.* Leaf-nosed Bats.

| | |
|---|---|
| Phyllostoma spectrum | Vampire or Spectre Bat. |

#### III. ORDER. Preying—*Sarcophaga.*

*Family.* Insect-eaters—*Insectivora.*

PLATE 5.

| | |
|---|---|
| Erinaceus Europæus | Common Hedgehog |
| Sorex araneus | Common Shrew |
| Talpa Europæa | Common Mole. |

*Family.* Sole-treaders—*Plantigrada.*

| | |
|---|---|
| Ursus maritimus | Polar Bear |
| Procyon lotor | Raccoon |
| Nasica fusca | Brown Coati |
| Gulo Americanus | Wolverine. |

*Family.* Toe-treaders—*Digitigrada.*

PLATE 6.

| | |
|---|---|
| Mustela fouina | Pine Martin |
| Mephitis Americana | American Skunk |
| Lutra vulgaris | Common Otter |
| Viverra civetta | Civet |
| Herpestes ichneumon | Egyptian Ichneumon. |

PLATE 7.

| | |
|---|---|
| Canis familiaris | (var.) Thibet Dog |
| lupus | Wolf |
| aureus | Jackal |
| vulpes | Fox |
| fennecus | Fennek. |

PLATE 8.

| | |
|---|---|
| Hyæna vulgaris | Striped Hyæna |
| Felis leo | Lion |
| tigris | Tiger. |

*Family.* Fin-footed—*Pinnata.*

PLATE 9.

| | |
|---|---|
| Phoca vitulina | Common Seal |
| Otaria nigra | Black Otary or Seal |
| Trichechus rosmarinus | Walrus. |

(a) This species is named in the plate as a *Cercopithecus*, in which genus it is included by Desmarest.

(b) This plate is unmarked.

(c) This order is marked on the plate as a family of the *Sarcophaga.*



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IV. ORDER. Pouch-bearers—*Marsupialia.*

*Family.* Flesh-eaters—*Carnivora.*

PLATE 10. (*a*)

| | |
|---|---|
| Dasyurus Maugei | Mauge's Dasyure. |

*Family.* Insect-eaters—*Insectivora.*

| | |
|---|---|
| Didelphis Virginiana | Virginian Opossum |
| Perameles obesula | Porcine Bandicoot or Peramele. |

*Family.* Fruit-eaters—*Frugivora.*

| | |
|---|---|
| Phalangista gliriformis | Mouse-like Phalanger. |

*Family.* Burrowers—*Fodientia.*

| | |
|---|---|
| Phascolomys fuscus | Wombat. |

*Family.* Long-footed Grazers or Leapers—*Salientia.*

PLATE 11.

| | |
|---|---|
| Hypsiprymnus murinus | Potooroo |
| Halmaturus vel Macropus } giganteus | Great Kangaroo. |

V. ORDER. Gnawers—*Rodentia.*

*Family.* Provided with perfect collar-bones—*Claviculata.*

PLATE 12.

| | |
|---|---|
| Hypudæus lemmus | Lemming |
| Myoxus avellanarius | Dormouse |
| Castor fiber | Common Beaver |
| Hydromys coypu | Molina's Coypu |
| Mus rattus | Black Rat |
| Dipus jaculus | Ægyptian Jerboa |
| Pedetes Capensis | Cape Jerboa |
| Arctomys Alpinus | Alpine Marmot. |

*Family.* Provided with imperfect collar-bones—*Hemiclaviculata.*

PLATE 13.

| | |
|---|---|
| Lepus timidus | Common Hare |
| —— pusillus vel Lagomys pusillus | } Calling Hare |
| Pteromys sabrinus | Great Flying Squirrel |
| Hystrix cristata | Common Porcupine. |

VI. ORDER. Toothless—*Edentata.*

*Family.* Slow-movers—*Tardigrada.*

PLATE 14. (*b*)

| | |
|---|---|
| Bradypus tridactylus | Aï or Three-toed Sloth. |

*Family.* Banded—*Cingulata.*

| | |
|---|---|
| Dasypus novemcinctus | Nine-banded Armadillo or Tatou. |

*Family.* Ant-eaters—*Myrmecophagida.*

| | |
|---|---|
| Myrmecophaga jubata | Great Ant-eater |
| Manis macroura | Long-tailed Pangolin or Manis. |

*Family.* With a single vent—*Monotremata.*

| | |
|---|---|
| Echidna hystrix | Spiny Echidna |
| Ornithorhynchus paradoxus | Rufous Ornithorhynque. |

VII. ORDER. Thick-skins—*Pachydermata.*

*Family* Trunked—*Proboscifera.*

PLATE 15. (*c*)

| | |
|---|---|
| Elephas Indicus | Indian Elephant |
| " " | Tooth of —— |
| —— Africanus | Tooth of African |
| Mastodon giganteum. (Fossil.) | Giant Mastodon |

*Family.* Trunkless—*Eproboscifera.*

PLATE 16. (*d*)

| | |
|---|---|
| Rhinoceros Indicus | Indian Rhinoceros |
| Tapirus Americanus | American Tapiir |
| Hippopotamus amphibius | Hippopotamus. |

VIII. ORDER. Single-toed—*Solipeda.* (*e*)

PLATE 18.

| | |
|---|---|
| Equus caballus | Horse |
| —— asinus | Ass |
| —— zebra | Zebra. |

IX. ORDER. Cud-chewers—*Ruminantia.*

*Family.* Camel-like—*Cameloida* seu *Acornua.*

PLATE 19.

| | |
|---|---|
| Camelus dromedarius | Dromedary |
| Auchenia glama | Llama |
| Moschus Javanicus | Java Musk. |

*Family.* Solid-horned—*Solidicornua.*

α With annually deciduous horns.

PLATE 20.

| | |
|---|---|
| Cervus alces | Elk or Moose Deer |
| —— tarandus | Reindeer |
| —— capreolus | Roebuck. |

β With permanent horns.

| | |
|---|---|
| Camelopardalis Giraffa | Camelopard or Giraffe. |

*Family.* Hollow-horned—*Cavicornua.*

PLATE 21. (*f*)

| | |
|---|---|
| Antilope cervicapra | Common Antelope |
| —— oryx | Ægyptian —— |
| —— pygmæa | Royal —— |
| —— picta | White-footed —— |
| —— gnu | Gnu. |

PLATE 22.

| | |
|---|---|
| Capra ibex | Ibex Goat |
| Ovis ammon | Wild Sheep |
| —— montana | Rocky Mountain Sheep |
| Bos Americanus | Bison. |

(*a*) The family name on this plate is *Pedimana*, from the thumb on the hind foot being moveable, as on the hand; but it is better to arrange them as here done.
(*b*) This plate, marked 24, should be 14.
(*c*) This plate, marked 25, should be 15.

(*d*) This plate, marked 23, should be 16.
(*e*) The ordinal name, *Pachydermata*, given on this plate, is wrong; it should be *Solipeda*. The "family Solidungula" should be erased.
There is not any plate 17.
(*f*) This plate is not numbered; it should be marked plate 21.

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X. ORDER. Cetacean—*Cetacea.*

*Family.* Grazers—*Herbivora.*

PLATE 23.

| | |
|---|---|
| Manatus Americanus | American Manatee |
| Halicore dugong | Dugong |
| Rytina Stelleri | Steller's Rytina. |

*Family.* Spouters—*Spiracularia.*

PLATE 24.

| | |
|---|---|
| Delphinus delphis | Common Dolphin |
| Monodon monoceros | Narwhal |
| Physeter macrocephalus | Cachalot or Spermaceti Whale |
| Balæna mysticetus | Common Greenland or Whalebone Whale. |

CLASS. BIRDS—*Aves* seu *Volitantia.*

I. ORDER. Preyers.—*Accipitrina.*

*Family.* Diurnal—*Diurna.*

PLATE 1.

| | |
|---|---|
| Vultur monachus | Monk Vulture |
| Sarcoramphus papa | King Vulture |
| Percnopterus Ægyptiacus | Egyptian Vulture |
| Gypaetos barbatus | Alpine Gypaëte. |

PLATE 2.

| | |
|---|---|
| Falco peregrinus | Peregrine Falcon |
| —— pennatus | Booted Buzzard |
| —— ossifragus | Sea Eagle |
| Gypogeranus Capensis | Cape Snake-eater. |

*Family.* Nocturnal—*Nocturna.*

PLATE 3.

| | |
|---|---|
| Strix nyctea | Snowy Harfang or Owl |
| —— aluco | Brown Owl |
| —— flammea | White Owl |
| —— otus | Long-eared Owl. |

II. ORDER. Perchers—*Passerina.*

*Family.* Tooth-billed—*Dentirostrata.*

PLATE 4.

| | |
|---|---|
| Lanius excubitor | Great Cinereous Shrike or Butcher-bird |
| Muscicapa grisola | Spotted Fly-catcher |
| Tanagra vittata | Banded Tanager |
| Turdus polyglottus | Mocking Bird |
| Rupicola aurantia | Orange Rock-Cock |
| Eurylaimus Javanicus. | |

*Family.* Wide-mouthed—*Fissirostrata.*

PLATE 5. (*a*)

| | |
|---|---|
| Hirundo rustica | Chimney Swallow |
| —— urbica | House Martin |
| —— esculenta | Esculent Swallow |
| Cypselus murarius (*b*) | Black Swift |
| Caprimulgus Europæus | European Goatsucker |
| —— macrodipterus | Leona Goatsucker. |

*Family.* Cone-beaked—*Conirostrata.*

PLATE 6.

| | |
|---|---|
| Alauda arvensis | Skylark |
| Parus caudatus | Long-tailed Titmouse |
| Emberiza hortulana | Ortolan |
| Fringilla cœlebs | Chaffinch |
| Loxia curvirostra | Crossbill |
| Corythus enucleator | Pine Grosbeak |
| Paradisæa apoda | Emerald Paradise-bird. |

*Family.* Slender-beaked—*Tenuirostrata.*

PLATE 7.

| | |
|---|---|
| Sitta Europæa | Nuthatch |
| Xenops rutilans | |
| Certhia familiaris | Common Creeper |
| Tichodroma muraria | Wall Creeper |
| Trochilus Delalandii | Delalande's Humming-bird |
| Upupa epops | Hoopoe. |

*Family.* Toe-tied—*Syndactyla.*

| | |
|---|---|
| Merops apiaster | Common Bee-eater |
| Alcedo ispida | Kingfisher. |

III. ORDER. Climbers—*Scansorialia.*

*Family.* Yoke-toed—*Zygodactyla.*

PLATE 8.

| | |
|---|---|
| Galbula macroura | Long-tailed Jacamar |
| —— grandis | Great Jacamar |
| Picus martius | Great black Woodpecker |
| —— tridactylus | Three-toed Woodpecker |
| Yunx torquilla | Wryneck |
| Picumnus minutissimus. | |

*Family.* Parrots—*Psittacida.*

PLATE 10. (*c*)

| | |
|---|---|
| Ara seu Macroceros aracanga | Scarlet Maccaw |
| Conurus solsticialis | Angola yellow Parrakeet |
| Psittacula pileata | Bonneted Psittacule |
| Psyttacus erythacus | Gray Parrot |
| Plyctolophus nasicus | Long-nosed Cockatoo |
| Microglossus Goliath | Gray small-tongued Parrot. |

IV. ORDER. Scratchers—*Gallinacea.*

*Family.* Poultry—*Gallinida.*

PLATE 12. (*d*)

| | |
|---|---|
| Gallus Sonnerati | Sonnerat's Cock |
| —— Macartneyi | Crested Cock |
| Phasianus Amherstiæ | Amherst's Pheasant |
| —— nycthemerus | Silver Pheasant |
| Tragopan Satyrus | Nepaul Horned Pheasant |
| Cryptonyx coronatus. | |

*Family.* Pigeons—*Columbida.*

PLATE 14. (*e*)

| | |
|---|---|
| Columba carunculata | Carunculated Pigeon |
| —— coronata | Crown-bird or Crowned Pigeon |
| Columba leucocephala | White-headed Pigeon |
| Vinago Wallia | Abyssinian Pigeon |
| —— calva | Bald-fronted Pigeon. |

(*a*) This plate is incorrectly marked Plate 6. Temminck calls this family *Chelidoneus*, or Pincher-clawed, from the form and description of their claws.

(*b*) This bird is wrongly named *Hirundo apus*, which was its old name.

(*c*) Plate 9 is deficient. Plate 10 has the family name marked *Zygodactyle*, it should be *Psittacida*. To the generic name should be added the others herein mentioned.

(*d*) Plate 11 is deficient.

(*e*) Plate 13 is deficient.

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### V. Order. Waders—*Grallatoria.*

#### *Family.* Short-winged. *Brevipennata* seu *Struthionida.*

Plate 15.

| | |
|---|---|
| Struthio camelus | Ostrich |
| Rhea Americana | Nandu |
| Casuarius galeatus | Cassowary |
| Dromiceius ater | Emeu. |

#### *Family.* Flat-beaked—*Pressirostrata.*

Plate 16.

| | |
|---|---|
| Otis tarda | Great Bustard |
| Œdicnemus crepitans | Common Thick-knee |
| Charadrius pluvialis | Golden Plover |
| Vanellus melanogaster | Grey Sand-piper |
| Hæmatopus ostralegus | Pied Oyster-catcher |
| Cursorius chalcopterus | Bronze-winged Courser |
| Dicholophus cristata | Marcgrave's Cariama. |

#### *Family.* Knife-beaked—*Cultirostrata.*

Plate 17. (*a*)

| | |
|---|---|
| Cancroma cochlearia | Boat-bill |
| Ardea major | Common Heron |
| —— egretta | Great Egret |
| —— stellaris | Bittern. |

Plate 18. (*b*)

| | |
|---|---|
| Ciconia alba | White Stork |
| Mycteria Senegalensis | Senegal Jabiru |
| Scopus umbretta | Tufted Umbre |
| Anastomus lamelligerus | Coromandel Erody |
| Tantalus lacteus | Milky Tantalus |
| Platalea aiaia | Roseate Spoonbill. |

#### *Family.* Long-toed—*Macrodactyla.*

Plate 20. (*c*)

| | |
|---|---|
| Parra Chinensis | Chinese Jacana |
| Palamedea cornuta | Horned Screamer |
| Pegapodius Freycineti | Freycinet's Mankirio |
| Morphyrio pulverulentus | Sultana-bird |
| Chionis necrophaga | White Sheathbill |
| Phœnicopterus ruber | Red Flamingo. |

### VI. Order. Web-footed—*Palmipeda.*

#### *Family.* Short-winged or Divers—*Brachyptera.*

Plate 21.

| | |
|---|---|
| Podiceps cornutus | Horned Grebe |
| Podoa Senegalensis | Senegal Coot-grebe |
| Colymbus glacialis | Northern Diver |
| Fratercula mormon | Puffin |
| Alca impennis | Great Auk |
| Aptenodytes Patagonica | Patagonian Penguin. |

#### *Family.* Long-winged—*Longipennata.*

Plate 22.

| | |
|---|---|
| Procellaria Hartie | Hartie's Petrel |
| Haladroma Berardi | Berard's Haladrome |
| Pachyptila vittata | Broad-billed Prion |
| Diomedea exulans | Wandering Albatross |
| Larus marinus | Black-backed Gull |
| Rhyncops nigra | Black Skimmer. |

#### *Family.* Splay-footed—*Steganopoda.* (*d*)

Plate 23.

| | |
|---|---|
| Pelicanus onocratalus | Common Pelican |
| Carbo cormoranus | Cormorant |
| Tachypetes aquilus | Great Frigate-bird |
| Sula alba | White Gannet |
| Plotus Levaillantii | Le Vaillant's Darter |
| Phaeton Phœnicurus | Red-tailed Tropic-bird. |

#### *Family.* Plaited-billed—*Lamellirostrata.*

Plate 24.

| | |
|---|---|
| Cygnus musicus | Wild Swan |
| Anser ferus | Wild Goose |
| Cereopsis Novæ Hollandiæ | New Holland Pigeon-goose |
| Anas clypeata | Shoveller |
| Hydrobates lobatus | Lobated Duck |
| Mergus merganser | Goosander. |

---

## Class. Reptiles—*Reptilia.*

### I. Order. Turtles—*Chelonia.*

Plate 1.

| | |
|---|---|
| Testudo Græca | Common Tortoise |
| Emys scripta | Written Fresh-water Tortoise |
| Sternothœrus trifasciatus | Three-striped Box-tortoise |
| Chelonia virgata | Striped Turtle |
| Chelys matamata | Matamata |
| Trionyx Nilotica | Nilotic Trionyx or Soft Tortoise. |

### II. Order. Crocodiles—*Champsia.*

Plate 2. (*e*)

| | |
|---|---|
| Rhamphostoma Gangeticus | (1) Indian Gavial or Crocodile |
| Crocodilus vulgaris | (2) Nilotic Crocodile |
| Champsa sclerops | (3) Spectacled Alligator |
| Heads of these kinds. | |

### III. Order. Lizards—*Sauria.*

#### *Family.* Lizard-like—*Lacertida.*

Plate 3.

| | |
|---|---|
| Tupinambis Nilotica | Nilotic Ouaran |
| Lacerta ocellata | Eyed Lizard. |

#### *Family.* Iguanas—*Iguanida.*

| | |
|---|---|
| Stellio vulgaris | Common Stellion |
| Draco lineatus | Striped Dragon |
| Iguana tuberculata | Common Guana |
| Anolis Capensis | Cape Anolis. |

#### *Family.* Geckos—*Geckotida.*

Plate 4.

| | |
|---|---|
| Gecko Ægyptiacus | Ægyptian Gecko. (*f*) |

#### *Family.* Chameleons—*Chamæleonida.*

| | |
|---|---|
| Chamæleo vulgaris | Common Chameleon. |

#### *Family.* Scinks—*Scincoida.*

| | |
|---|---|
| Scincus officinalis | Officinal Scink |
| Seps tridactylus | Three-toed |
| Bipes lepidopus | |
| Chirotes propus. | |

(*a*) This plate is marked 58, and must be altered to 17.
(*b*) This plate is marked 17, and must be altered to 18.
(*c*) Plate 19 is deficient.
(*d*) This family is called by Cuvier *Totipalmati*, from all the toes being included within the web.

(*e*) In this plate, fig. 2 only is a *Crocodile*; the upper one is a *Gavial*, and the lower an *Alligator*; they are, therefore, to be corrected.
(*f*) In this plate, the names, both generic and specific, *Stellio Ægyptiacus*, are wrong, and must be corrected as here given.

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IV. ORDER. Serpents—*Ophidia*.

*Family*.

PLATE 5.

Pseudopus Pallasii.

*Family*. Snakes.

Amphisbæna alba
Tortrix Scytale.

*Family*. Serpents, or Unpoisonous True Snakes.

| | |
|---|---|
| Boa constrictor | |
| Python poda | |
| Acrochordus Javanensis | Java Oularcaron. |

*Family*. Fanged Poisonous Snakes. (*a*)

PLATE 6.

| | |
|---|---|
| Crotalus horridus | Banded Rattle-snake. |
| Vipera berus | |
| Cerastes Hasselquistii. | |

*Family*. Fangless Poisonous Snakes.

| | |
|---|---|
| Naja lutescens | Yellowish Hooded Snake |
| Trimeresurus microcephalus | |
| Pelamides bicolor | |
| Pseudo-boa seu Bongarus fasciatus. | |

*Family*. Naked Snakes.

Cæcilia glutinosa.

---

V. ORDER. Frogs—*Batrachia*.

*Family*. Tailless—*Ecaudata*.

PLATE 7.

| | |
|---|---|
| Rana esculenta | Edible Frog |
| Ceratophrys varius | Horned Frog |
| Hyla vulgaris | Tree Frog |
| Bufo vulgaris | Common Toad |
| —— bombina | Yellow-bellied Toad |
| Pipa Surinamensis | Surinam Pipa. |

*Family*. Tailed—*Caudata*.

PLATE 8.

| | |
|---|---|
| Salamandra maculosa | Spotted Salamander |
| Triton marmorata | Marbled Newt or Eft |
| Salamandrops Alleghanensis | Menopome or Hellbender |
| Siredon Axolotl | Axolotl |
| Proteus anguinus | Snake-like Proteus |
| Siren lacertina | Lizard-like Siren. |

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## CLASS. FISHES—*Pisces seu Natantia*.

### A. BONY FISHES.—*Pisces Ossei*.

1. ORDER. Spine-finned—*Acanthopterygia*.

*Family*. Perch—*Percoida*.

PLATE 1.

| | |
|---|---|
| Perca fluviatilis | Perch |
| Trachinus draco | Common Weever |
| Mullus barbatus | Smaller Red-beard. |

*Family*. Gurnards—*Trigloida*.

| | |
|---|---|
| Trigla gurnardus | Red Gurnard |
| Dactylopterus Mediterraneus. | |

*Family*. Maigres—*Sciænida*.

| | |
|---|---|
| Sciæna umbra | |
| Amphiprion ephippium | Saddle-fish. |

*Family*. *Sparoida*.

PLATE 2.

| | |
|---|---|
| Sargus annularis | Ringed Sparus |
| Dentex vulgaris | Sea Rough. |

*Family*. *Mænoida*.

| | |
|---|---|
| Mæna vulgaris | Cockerell |
| Smaris vulgaris | Pickarell. |

*Family*. Scaly Fins—*Squammipinnata*.

| | |
|---|---|
| Chætodon striatus | Streaked Chetodon |
| Brama atropos. | |

*Family*. Mackarels—*Scomberoida*.

PLATE 3.

| | |
|---|---|
| Scomber scomber | Mackarel |
| Xiphias Gladius | Sword-fish |
| Zeus faber | Doree. |

*Family*. Band-fish—*Tænioida*.

| | |
|---|---|
| Trichiurus lepturus | Hairtail |
| Stylephorus chordatus | |
| Cepola rubescens | Red Band-fish. |

*Family*. Theutyes—*Theutida*.

Amphacanthus guttatus.

*Family*. *Labyrinthiformia*.

PLATE 4.

| | |
|---|---|
| Anabas testudineus | Climbing Perch |
| Ophicephalus punctatus | Dotted Snakehead. |

*Family*. Mullets—*Mugiloida*.

| | |
|---|---|
| Mugil cephalus | Mullet. |

*Family*. Gobies—*Gobioida*.

| | |
|---|---|
| Blennius ocellaris | Butterfly-fish |
| Anarhicas lupus | Wolf-fish |
| Gobius niger | Black Goby. |

*Family*. Anglers—*Pectoralipeda*.

PLATE 5.

| | |
|---|---|
| Lophius piscatorius | Common Angler |
| Batrachus Surinamensis | Surinam Toad-fish. |

*Family*. Wrasses—*Labroida*.

| | |
|---|---|
| Labrus carneus | Red Wrasse |
| Scarus Creticus | Cretan Scarus. |

*Family*. Pipe-fish—*Aulostomata*.

| | |
|---|---|
| Fistularia tabacaria | Tobacco-pipe-fish |
| Centriscus scolopax | Sea Woodcock. |

(*a*) This and the following family are included on the plate under the common name *Venomosa*, but they are better divided as here, after Müller's arrangement.

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II. ORDER. Abdominal Soft-fins—*Hetro-Malacopterygia.* (*a*)

*Family.* Carps—*Cyprinoida.*

PLATE 6.

| | |
|---|---|
| Cyprinus carpio | Carp |
| Cobitis fossilis | Muddy Loach |
| Anabieps tetropthalmus. | |

*Family.* Pikes—*Esocida.*

| | |
|---|---|
| Esox lucius | Pike |
| Exocœtus exiliens | Flying-fish. |

*Family.* *Siluroida.*

| | |
|---|---|
| Silurus glanis | Sheet-fish |
| Pimelodes cyclopum | |
| Loricaria cirrhosa. | |

*Family.* Salmons—*Salmonida.*

PLATE 7.

| | |
|---|---|
| Salmo salar | Salmon |
| Argentina sphyræna | Argentine |
| Saurus fœtens | Fetid Saury. |

*Family.* Herrings—*Clupeoida.*

| | |
|---|---|
| Clupea harengus | Herring |
| Gnathobolus aculeatus | |
| Polypterus bichir. | |

III. ORDER. Throat Soft Fins—*Læmo-Malacopterygia.* (*b*)

*Family.* Cod—*Gadoida.*

PLATE 8.

| | |
|---|---|
| Gadus morrhoa | Cod-fish |
| Phycis Mediterraneus | Mediterranean Fork-beard. |

*Family.* Flat Fish—*Pleuronectoida.*

| | |
|---|---|
| Platessa vulgaris | Plaice |
| Rhombus megastoma | Whiff |
| Solea vulgaris | Sole. |

*Family.* Suckers—*Discobolida.*

| | |
|---|---|
| Lepidogaster Cornubiensis | Cornish Sucker |
| Echeneis remora | Common Remora. |

IV. ORDER. Without Ventral Fins—*Apodo-Malacopterygia.*

PLATE 9.

| | |
|---|---|
| Anguilla acutirostris | Sharp-nosed Eel |
| Conger vulgaris | Conger |
| Ophisurus hyala | Glassy Ophisure, |
| Muræna meleagris | |
| Sphagebranchus rostratus | |
| Saccopharynx Harwoodii | |
| Gymnonotus æquilabiatus | Banded Gymnote |
| Leptocephalus Morrisii | Anglesea Morris |
| Ophidium imberbis | Beardless Ophidium |
| Ammodytes lancea | Sand-lance. |

V. ORDER. Hoop Gills—*Lophobranchiata.*

PLATE 10.

| | |
|---|---|
| Syngnathus typhlus | Needle-fish |
| Pegasus draco | Sea Dragon. |

VI. ORDER. Fixed Jaws—*Plectognatha.*

*Family.* Naked Teeth—*Gymnodonta.*

| | |
|---|---|
| Diodon hystrix | Round Diodon |
| Orthragoriscus oblongus. | |

*Family.* Hard Skins—*Sclerodermata.*

| | |
|---|---|
| Balistes capriscus | Mediterranean File-fish |
| Ostracion triquetrum | Trunk-fish. |

B. CARTILAGINOUS FISHES.—*Pisces Chondropterygii.*

ORDER. Loose Gills—*Eleutherobranchiata.*

*Family.* Sturgeons—*Sturionida.*

PLATE 11.

| | |
|---|---|
| Accipenser sturio | Sturgeon |
| —— ruthenus | Sterlet |
| Polyodon folium | |
| Chimæra monstrosa (*c*) | |
| —— callorhyncha. (*c*) | |

ORDER. Close Gills—*Pycnobranchiata.*

*Family.* Transverse Mouths—*Plagiostomata.*

PLATE 12.

| | |
|---|---|
| Squalus carcharius | White Shark |
| Squatina angelus | Angel-fish |
| Torpedo narke | Spotted Torpedo |
| Raja clavata | Rough Ray. |

*Family.* Lampreys or Round Mouths—*Cyclostomata.*

| | |
|---|---|
| Petromyzon marinus | Sea Lamprey |
| Gastrobranchus cæcus | Myxine or Hag. |

(*a*) The coupling of the Latin derivative, Abdominal, with the Greek, Malacopterygian, by Cuvier, is a sad barbarism; it were certainly preferable to use the word *Hetro*, from the Greek ἦτρον, a belly, indicating the position of the fins.

(*b*) Here, as in the last order, Cuvier makes a compound Latin word, Subbrachian, and joins it with a Greek one; instead of which it is proposed to employ the word Læmo, from the Greek λαιμός a throat, indicating, as before, the position of the fins.

(*c*) Though the *Chimæræ* are placed by Cuvier with the Sturgeons, yet Richardson has very properly observed that their place "belongs to his (Cuvier's) second order of *Chondropterygii*, in which the gills are fixed."

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## B. INVERTEBRATE SERIES.

### CLASS. MOLLUSCS (*a*)—*Mollusca*.

A. SUB-CLASS. Head-walkers, or Cuttle-fish—*Cephalopoda*. (*b*)

PLATE 1.

Argonauta raricosta
—— argo.

B. SUB-CLASS. Belly-walkers—*Gasteropoda*.

ORDER. Air-breathers—*Pulmonifera*. (*c*)

PLATE 2.

Limax maximus vel antiquorum Gray Slug
—— variegatus Variegated Slug
Testacella Maugei
Helix naticoides
—— Japonica
—— algira
—— carocolla
—— nux denticulata
—— albella
—— epistyllium
Bulimus ovatus
Pupa
Clausilia
Achatina virginea
Physa rivalis.

ORDER. Naked Gills—*Gymnobranchiata* seu *Nudibranchiata*. (*d*)

PLATE 3.

Doris trilobata
—— lacinata
—— nodosa
—— pennigera
—— limbata
—— tuberculata
—— cornuta
—— atro-marginata
Onchidorus Leachi
Peronia Mauritania
Polycera quadricornis
Tritonia Hombergii
Thethys leporina
Scyllæa pelagica
Glaucus Atlanticus
Laniogerus Elfortii
Eolidia Cuvieri
Cavolina perigrina
Tergipes.

ORDER. Covered Gills—*Tectibranchiata*. (*e*)

PLETA 4.

Pleurobranchus Peronii
Lamellaria membranacea
Aplysia punctata
Dolabella Rumphil
Notarchus Cuvieri
Acera carnosa
Bullæa aperta
Bulla lignaria
Bullina Guianensis
Umbrella Indica.

ORDER. Comb-gills-*Pectinibranchiata*.

PLATE 5. (*f*)

a. Trochoid Tribe.

Monodonta (animal of)
Trochus Henslovii
—— Emma
Imperator
Paludina fasciata
—— costata
Littorina littoralis
Phasianella bulimoides
Ampullaria solida
Melania Bironensis
Natica millepunctata
Nerita undulosa
—— cariosa
Neritina Ovenii.

b. Buccinoid Tribe.

Cerithium Lamarckii
—— fuscatum
—— telescopium (opercule of)

PLATE 6. (*g*)

c. Capuloid Tribe.

Capulus Hungaricus
Pileopsis mitrula
—— crenulata
Hipponix cornucopiæ
Dispotæa Bironensis
Crepidula porcellana
—— Peruviana
—— unguis
Calyptræa Neptuna
Siphonaria radiata
—— gigas
Gadinia
Sigaretus haliotideus
Coriocella nigra.

SUB-CLASS. Headless—*Acephala*.

PLATE 7. (*h*)

ORDER. *Heterobranchiata*. (*i*)

Cynthia momus
—— canopus
Botryllus polycyclus
Polyclinum constellatum
Sigillina Australis
Distoma rubinm
Sinoicum turgens.

SUB-CLASS. *Cirrhopoda*.

PLATE 8. (*i*)

ORDER. Peduncular—*Camptosomata*.

Pentalasmis vulgaris
Cineras vittata
Otion Cuvieri
Scalpellum vulgare
Polliceps cornucopiæ.

ORDER. Sessile—*Acamptosomata*.

Tubicinella Lamarckii
Coronula Diadema
Chelonobia Savignii
Pyrgoma cancellata
Creusia Spinulosa
Acasta Montagui
Balanus tintinnabulum
Balanus
Conia valgaris
Clisia verruca.

(*a*) All the plates of this class have been very oddly arranged and named,—scarcely any are numbered; the reference, therefore, must be made to the heading, which will require alteration.

(*b*) This plate, headed *Class* Cephalopoda, *Order* Octopoda, must be numbered Plate 1, and the word Class changed for Sub-class.

(*c*) This plate, headed *Class* Gasteropoda, *Order* Pulmonifera, must be numbered Plate 2, and the word Class changed for Sub-class.

(*d*) This plate, headed *Class* Lepadophora, *Order* Gymnobranchia, must be numbered Plate 3; and the words Class, &c. changed for Sub-class Gasteropoda.

(*e*) This plate, headed Mollusca III *Class* II. Cochleophora, *Order* Tectibranchiata, must be numbered Plate 4. The numeral III. after Mollusca to be erased, as also Class II. Cochleophora; and in place of the latter insert Sub-class Gasteropoda.

(*f*) This plate, headed *Class* Cochleophora, *Order* Pteuobranchia, to be marked Plate 5. In place of Class, &c., insert Sub-class Gasteropoda; and instead of Pteuobranchia, insert Pectinibranchiata.

(*g*) This plate, headed Mollusca IV. *Class* Conchophora, *Order* Tectibranchia, must be numbered Plate 6; the numeral IV. struck out, as also Class, &c.; in its place Sub-class Gasteropoda and Pectinibranchiata to be inserted in place of Tectibranchia. In this and the next plate read Tribe instead of Family.

(*h*) This order forms the Tunicata of Lamarck—Is to be marked Plate 7.—In place of *Class* Tunicata, insert Sub-class Acephala, and on opposite side Order Heterobranchiata.

(*i*) This is marked Plate I; but as there is not another, Plate 1 may be erased. For the word Class substitute Sub-class.



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## CLASS. INSECTS.

### I. ORDER. Sheathed-winged—*Coleoptera.*

PLATE 1. (*a*)

Lucanus Cervus — Stag-beetle
Lampyris noctiluca (male 2, female 3,) — Glow-worm
Cerambyx.

### II. ORDER. Straight-winged—*Orthoptera.*

Gryllotalpa vulgaris — Common Mole-cricket
Blatta Lapponica — Lapland Cockroach
Forficula vulgaris — Common Earwig
Gryllus cærulescens
Mantis striata.

### III. ORDER. Lace-winged—*Neuroptera.*

Myrmeleo formicarius (in different stages)
Libellula depressa (larva of)
Nemoptera vulgaris
Ascalaphus barbarus.

### IV. ORDER. Membranous-winged—*Hymenoptera.*

Sphex spirifex
Urocerus gigas
Pomphylus viaticus.

### V. ORDER. Soft or Feather Winged—*Lepidoptera.*

PLATE 2.

Lycæna dispar (in various stages)
Hesperia comma
Noctua delphinula
Bombyx dispar
—— furcula (in two states).

### VI. ORDER. Half-winged—*Hemiptera.*

Fulgora candellaria — Lantern-fly
Naucoris cimicoides
Notonecta glauca — Boat-fly
Coccus cacti
Aphis rosæ (in two states).

### VII. ORDER. Two-winged—*Diptera.*

Echinomya fera
Hirtea pomona
Cenogastra mystacinus
Ceroplatus tipuloides
Thereva crassipennis
Tabanus niger
Diopsis ichneumonea.

### VIII. ORDER. Wingless—*Aptera.*

Pulex irritans (male and female) — Common Flea
—— penetrans (in different stages) — Chigoe.

### I. ORDER. Coleopterous Insects. (*b*)

PLATE 3.

Authia quadriguttata
Elaphrus uliginosus
Omophron limbatum
Hydrous piceus
Necrophorus vespillo
Tachys minuta
Passalus interruptus
Chiasognathus Grantii
Drilus flavescens
Tillus mutilarius
Enicopus niger
Uleiota flavipes
Callichroma alpina
Molorchus abbreviatus
Rhagium mordax
Cerocoma Schoefferi
Homalysus suturalis
Notoxus monocerus
Lomechusa dentata

PLATE 4.

Helophorus aquaticus
Scaphidium quadrimaculatum
Necrodes littoralis
Anthicus pedestris
Nitidula grisea
Apate capuzina.

### II. ORDER. Orthopterous Insects.

Tridactylus paradoxus
Truxalis nasuta
Acridium bipunctatum.

### III. ORDER. Neuropterous Insects.

Lestes autumnalis
Raphidia notata
Ephemera vulgata
Panorpa vulgaris.

### IV. ORDER. Trichopterous Insects.

Limnephilus griseus.

### V. ORDER. Hymenopterous Insects.

Banchus pictus
Evania appendigaster
Scolia quadrimaculata
Mutilla coccinea
Ichneumon manifestator
Pterygophorus cinctus
Masaris apiformis.

### VI. ORDER. Lepidopterous Insects.

PLATE 5.

Fidonia melanaria
Earis clorana
Crambus margaritellus
Harpipteryx harpella (two states)
Adela sultzella.

### VII. ORDER. Dipterous Insects.

Ceria conopsoides
Henops marginatus
Anthrax moria.

### VIII. ORDER. Hemipterous Insects.

Tingis vinarum
Lygæus militaris
Tetyra nigrolineata
Syrtis paradoxus
Berytus tipularis
Hydrometra stagnarum
Genis lacustris.

### IX. ORDER. Homopterous Insects.

Lystra lanuginosa
Flata alba
Delphax pellucidus
—— dorsatus
Thryps cœruleocollis.

### X. ORDER. Strepsipterous Insects.

Stylops melittæ
—— Kirbii
—— Dalii
Halictophagus Curtisii
Elenchus Walkeri
Xenus vesparum.

## CLASS. CRUSTACEANS—*Crustacea.*

(One) PLATE.

### I. ORDER. Short Tails—*Brachyura.*

Grapsus pictus
Phyllosoma clavicornis

### II. ORDER. Long Tails—*Macroura.*

Pagurus Bernardus — Hermit Crab.

### III. ORDER. Footed Mouths—*Stomapoda.*

Squilla mantis.

### IV. ORDER. Equal Legs—*Isopoda.*

Cymodoce Lamarckii
Porcellus asellus.

### V. ORDER. Footed Gills—*Branchiopoda.*

Polyphemus stagnalis
Daphnia pulex
Lepidurus prolongus
Brachipus stagnalis.

(*a*) Neither this nor the next plate is numbered; they must, therefore, be marked as indicated above. This arrangement is Lamarck's.

(*b*) This second set of Insects indicates their arrangement into a greater number of Orders.

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CLASS. ARACHNIDANS—*Arachnida.*

(One) PLATE.

I. ORDER. Fringed Tails—*Thysanoura.*

Forbicina vittata
Podura villosa.

II. ORDER. Spiders—*Araneida.*

Mygale avicularis
Aranea extensa
—— lobata

III. ORDER. Scorpions—*Chelifera.*

Scorpio rufescens
Chelifer cancroides.

IV. ORDER. Mites—*Acarida.*

Smaridia fringillaris
Siro rubens.

CLASS. MYRIAPODS—*Myriapoda.*

Polydesma complanata
Lithobia vulgaris

Glomeris zonatus
Julus sabulosus.

CLASS. SPINED SKINS(*a*)—*Echinodermata.*

I. ORDER. Sea Urchins—*Echinoida.*

*Family.* Cidaroid.

PLATE 1.

Diadema fistularis
Cidaris imperialis
Astropyga radiata.

*Family.* Echinoid.

Echinus miliaris
—— elegans
—— sardicus
Echinometra mammillatus.

*Family.* Scutelloid.

PLATE 2.

Echinanthus subdepressa
Echinarachnius placenta
Echinodiscus digitata
Cassidulus Australis.

*Family.* Galeritidans.

Galerites albo-galerus
Echinanaus minor
Echinolampas Kœnigii
Echinocorys ovatus
Echinobryssus Breynii.

*Family.* Spatangoid.

Echinodardium Atropo
Spatangus purpureus
Brissus unicolor.

II. ORDER. Stelleridans—*Stellerida.*

PLATE 3. (*b*)

Asterias pulchella
—— cylindrica
Ophiura mutica
—— Lamarckii
—— squamosa
—— lineolata
Euryale simplex.

CLASS. SEA NETTLES OR ACALEPHS—*Acalepha.*

I. ORDER. Siphon-bearers—*Siphonophora.*

(One) PLATE.

Diphya
Rhizophysa planostoma
Physsophora disticha
Physalia megalista
Velella cyanea
Porpita gigantea.

II. ORDER. Umbrella-bearers, or *Sciaphora.*

Berenice rosea
Geryonia hexaphilla
Pelagia panopyra
Æquorea Forskaelena
Aurelia aurita
Rhizostoma Cuvieri.

III. ORDER. Crest-bearers, or *Ctenophora.*

Beroe macrostoma
Callianira triploptera
Cestum Veneris.

CLASS. INFUSORIES.

SUB-CLASS. Many Stomachs—*Polygastrica.*

I. ORDER. Anenterous.

PLATE 1.

Monas crepusculum
—— guttula
Uvella virescens
Doxococcus globulus
Chilomonas volvox
Bodo socialis
Cryptomonas ovata
Trachelomonas volvocina
Gyges granulum
Syncrypta volvox
Sphærosira volvox
Volvox globata
Vibrio subtilis
Spirodiscus fulvus
Closterium lunula
Astasia hæmatodes
Englena viridis
Distigma tenax
Epipyxis utriculus
Dinobrion sertularia
Amœba diffluens
Difflugia Proteiformis
Cypidium aureolum
Desmidium Swarzii
Xanthidium fasciculatum
Micrasterias Boryana
Euastrum aculeatum
Navicula phœnicentron
Bacillaria vulgaris
Isthmia enervis
Syndera ulna
Echinella splendida
Syncycha salpa
Naunema Dilwynii
Schizonema Aghardi
Cyclidium glaucoma
Chætomonas constricta
Chætophyla armata
Chætoglena volvocina
Peridinium tripos
Glenodinium tabulatum.

(*a*) Marked incorrectly on the plates Echinida.
(*b*) This plate is to be numbered 3. Radiata and *Class* Stellerida to be erased, and in their place Echino-dermata, *Order* Asteroida to be inserted.



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II. Order. Enterodelous.

Stentor Mülleri
Urocentrum turbo
Vorticella microstoma
Zoothamnium arbuscula
Ophrydium versatile
Tintinnus inquilinus
Vaginicola chrystallina
Enchelys pupa
Lachrymaria proteus
Leucophrys patula
Prorodon teres
Coleps incurvus
Trachelius ovum
Phialina vermicularis
Chilodon cucullus
Nassula elegans
Trachelocerca olor
Aspidisca denticulata
Amphileptus fasciola

Plate 2.

Colpoda ren
Ophryglena acuminata
Oxytricha cicada
Stylonychia pustulata
Discocephalus rotatorius
Chlamidodon Mnemosyne
Euplotes Charon.

Sub-class. Rotatories.

I. Order. Monotrochous.

Ptygura melicerta
Icthydium podura
Chætonotus maximus
Glenophora trochus
Oeistes hyalinus
Cyphonautes compressus
Microcodon clavus
Tubicolaria najas
Floscularia ornata
Melicerta ringens
Lymnas ceratophylli.

II. Order. Sorotrochous.

Hydatina trachydactyla
Furcularia gibba
Diglena grandis
Triopthalmus dorsalis
Cycloglena lupus
Lepadella ovalis
Euchlanis luna
Colurus caudatus
Squamella oblonga
Callidina elegans
Rotifer macrurus
Philodina aculeata
Noteus quadricornis
Anuræa squamula
Brachionus amphiceros
Pterodina patina.

Class. Polyps. (a)

Cornicularia rugosa
Tubipora musicalis
Renilla Americana
Tubularia elytoidea
Corallium rubrum
Gorgonia patula
Millepora spongitis
Bicellaria fastigiata
Serialaria lengidera
Cellepora hyalina
Laomedia dichotoma
Plumaria secundaria
Sertularia pumila
Caryophyllea solitaria
Meandrina limosa
Zoanthus Ellisii
Astrea ananas
Meandrina cerebriformis
Oculina varicosa
Actinia dianthus.

(a) This plate is marked "Zoophytes," and should be altered.

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# ANATOMY.

Anatomy. The term "Anatomy," in its most correct and extensive sense, implies the examination of the structure and economy of the several parts and organs not only of animal but also of vegetable bodies. In its more restricted and conventional employment, however, it is applied specially to that branch of the Science which treats of the fabric of the human body, and the organs of which it consists. The description of the tissues composing the several organs has been already given in the Essay on Zoology; it therefore remains to consider the form and arrangement of the organs themselves, which is the province of Descriptive Anatomy.

## SECTION I.

### OF THE BONES AND THEIR APPENDAGES,—*viz.*, LIGAMENTS, CARTILAGES, AND SYNOVIAL MEMBRANES.

The natural junction of the Bones by ligaments, cartilages, and synovial membranes, forms the Skeleton (Anat. Pl. I. and II.), which serves three purposes; *first*, as a frame-work upon which the soft parts are at once extended and supported; *second*, as furnishing cavities for the entire or partial lodgment and protection of the more important organs; and, *third*, as providing a series of levers for the motions of the whole or any part or parts of the body. The first office is performed by the whole Skeleton; the second by the Head, Spine, Chest, and Basin; and the third by the Limbs. The division of the Human Skeleton into the three principal parts,—trunk, head, and limbs,—corresponds generally with that of the other Vertebrate Classes, but modified in reference to its special condition and economy, which is mainly influenced by the erect posture, by station on the hinder, or rather lower limbs, thereby allowing free use of the fore or upper limbs without interference with the carriage or locomotion of the body, and by the great development of the cerebral portion of the brain, which produces correspondent size and form in the skull.

#### 1.—OF THE SPINE.

*Columna Vertebralis*, Lat.; *der Ruckgrat*, Germ.; *la Colonne Vertébrale*, Fr. (Anat. Pl. III., fig. I. to XVII.)

The Spine or Backbone consists of twenty-six Vertebres, piled one above another, and forming an irregular pillar, often called the Spinal or Vertebral Column (figs. XII. XIII. XIV.). Each Vertebre (fig. I. to X.) (*Vertebra*, Lat.; *Wirbel*, Germ.; *Vertèbre*, Fr.) has an irregularly-shaped short cylindrical body (a.), behind which is the spinal hole (b.) produced by the arch-like junction of the seven processes with the back of the body. Of these processes the two transverse (c. c.), which stand out from each side of the arch, and the spinous (d.) from its back, serve the purpose of levers; whilst the other four, viz., two upper articular processes (e. e.) facing backwards, and two lower (f. f.) looking forwards, link the vertebral pieces together. The spinal canal, which runs from end to end of the vertebral column, results from the piling upon each other of the rings forming the spinal holes, and lodges the spinal marrow; the apertures on each side of it for the passage of the spinal nerves are produced by the conjunction of the notches at the roots of the articular processes, with corresponding notches of the Vertebres above and below each bone.

The Spine is anatomically divided into regions, commonly known as the neck, back, loins, and rump; to the Cervical or neck (figs. XII. XIII. XIV. a.) belong seven Vertebres; to the Dorsal or back (b.), twelve; to the Lumbar or loins (c.), five; and to the rump (d. e.), two, of which the upper piece (d.) is the true rump-bone, and the lower (e.) the rudiment of the tail-bones of other Vertebrate Animals. These Vertebres in their several regions perform peculiar offices; hence their form varies, and their specific characters easily distinguish them; but the nearer each region approaches the other, the more nearly does one resemble the other, and therefore the special form is best developed in the central pieces of each division.

Of the Neck (*Cervix*, Lat.; *der Hals*, Germ.; *le Cou*, Fr.) (Figs. IV. V. VI. VII).

The principal use of this region being mobility, the Vertebres of which it consists are formed specially with that object; accordingly their bodies (a.) are of small size, and their lever-like transverse (c. c.) and spinous (d.) processes large. The upper (g.) and under surfaces of their bodies are so formed as to allow greater extent of motion than in any other part of the Spine, the upper being hollowed from side to side and the under from before to behind, so that when the bones are connected by their ligaments, a chain-like motion is performed, and thereby great mobility provided without loss of strength or connexion. The articular processes face obliquely the upper (e. e.) upwards and backwards, the lower (f. f.) downwards and forwards; hence the term "oblique," sometimes applied generally but improperly to the articular processes of all Vertebres, is to these specially appropriate. They are also more or less hollowed, and permit sliding on each other in the inclination of the head forwards and backwards, or to either side. These motions are confined to the six lower Vertebres of this division; and although between any two they are not extensive, yet is the combined motion of all very considerable. The transverse (c. c.) and spinous (d.) processes are each



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Anatomy. bifid, *i. e.*, terminating in a fork-like form, and hence they admit of very minute degrees of motion by the operation of single portions of the muscles attached to them, whilst the horizontal direction, which they generally affect, allows considerable motion backwards, forwards, or aside, before the processes strike upon each other. In each transverse process is a hole (i.), and through the upper six Vertebres the vertebral artery on each side ascends to the brain; but in the seventh, the holes give passage to a pair of veins from the venous trunks of the Spinal Marrow, which portion of the Nervous System being of considerable bulk whilst passing through the Neck, the spinal holes forming the canal are of correspondent size, the largest among all the Vertebres, and of triangular shape.

In addition to the variation of the typical form of the Neck Vertebres as they approach the back, the uppermost two exhibit some very remarkable characters in consequence of the partial revolution of the head upon the Spine. This motion does not occur, as might at first be supposed, between the head and the first Cervical Vertebre, but between the first and second pieces of the Neck, the head being so intimately connected with the former as to allow but very slight motion. Strictly speaking, therefore, with respect to motion, the first Neck Vertebre should be considered as an appendage to the head, and the second as the commencement of the Spinal Colomn, for which reason its description will precede that of the former.

The Second Neck Vertebre, or *Pivot* (fig. IV.), is so called from a stout pivot or tooth-like process (j.) springing up from the top of its body. Its transverse processes are small, but the spinous very bulky, as might be expected from the strong muscles attached to and acting upon it: its superior articular processes are very extensive. The pivot-like process is received into

The First Neck Vertebre, or *Atlas* (figs. V. and VI.), so called from supporting the head. It is little more than a mere ring with a pair of deep sockets on its upper outer edges, into which the condyles of the skull are received, and another pair of broad flat ones below, joining it with the corresponding processes of the Second Vertebre; whilst the fore part, which in the other Vertebres forms the body, is hollowed out into an arc (g.), the radius of which faces backwards, is only naturally perfected by a strong ligament, and thereby separated from the spinal canal. Into this hole the pivot of the Second Vertebre is received, and upon it the Atlas to a certain extent revolves. As the rotatory motion of the head is thus really performed by the Atlas, the transverse processes (e. e.) are especially developed, and jut out far beyond those of any other of the Neck Vertebres. Flexion and extension being scarcely, if at all, performed either between the Second and First Vertebre, or between the latter and the head, the spinous process of the First Vertebre is a mere stud.

The Seventh Neck Vertebre also differs from the others by its nearer approximation to those of the back in its transverse and spinous processes, being single, and the latter being hooked much downwards, so that it has little rotatory motion.

### Of the Back (*Dorsum*, Lat.; *der Rücken*, Germ.; *le Dos*, Fr.) (Figs. I. II. III.)

The Vertebres composing the Dorsal Region of the Spine present a marked difference of form when compared with that of the Cervical, in which, as already Anatomy. noticed, the mechanism was specially with reference to motion, whilst in these the arrangement of the several parts is in relation to firmness, and to afford fixed points upon which the motions of the ribs may be performed. The former object, firmness, is effected by the great hooking down of the spinous processes (d.), which, overlapping each other like tiles, prevent any rotatory motion, and admit only of a little lateral inclination, with flexion and extension, but in a slight degree. To the latter intent the transverse processes (e. e.), which are horizontal and directed backwards so as to increase the capacity of the chest from behind to before, are single, and have articular surfaces (k.) for the angles of the ribs, the heads of which are further connected with the Spine by articular surfaces or hollows on the sides of the bodies of the Vertebres formed by the junction of two, each of the Vertebres having on either side at the upper and lower edge of its body a half articular surface (l. m.), which, being joined to that of the superjacent and subjacent Vertebre, forms a socket for the head of a rib. The articular processes (e. e. f. f.) are vertical and nearly plane, and thereby present an additional obstacle to other than flexion, extension, and lateral inclination.

Variations are also observed from their general form in these Vertebres. Whilst the eight following the first have each a half socket for the ribs on the upper and lower edges of the bodies, so that a pair of ribs is supported by two Vertebres, the first has a pair of whole ones for the first pair of ribs, besides the pair of half ones for the second; the tenth has only a pair of half sockets for the tenth pair of ribs, whilst the eleventh and twelfth have each a pair of whole sockets supporting the corresponding pair of ribs, which are therefore connected only with one instead of two Vertebres. The eleventh and twelfth dorsal Vertebres are also further distinguished by the small size of their transverse processes, which resemble those of the loins, leading gradually to the greater and more varied motions of the latter division of the Spine. The first Back Vertebre is characterized by having at its upper part a pair o whole articular surfaces for the first pair of ribs, besides the pair of half ones belonging to the second ribs. It is almost immovable, forming at the same time a base upon which the motions of the Neck are performed, and a point from whence the motions of the ribs are primarily derived.

### The Loins (*Lumbus*, Lat.; *die Lende*, Germ.; *les Lombes*, Fr.) (Figs. VIII. IX.)

In the Loins the movement of the several Vertebres upon each other is very extensive, and more varied than in the back. The greater part of the motions of the trunk upon itself are here performed, consisting of flexion, extension, and swaying to either side, or a combination of all these movements, producing in the upper part of the trunk a motion corresponding with that of the upper free moving end of a rod, of which the lower moves only upon its own axis in a cup. The lateral inclination is allowed by the small size of the transverse, and facilitated by the form of the articular processes, the lower of which (f. f.), each resembling the vertical section of a solid cylinder, are received into corresponding but concave half cylinders, which form the upper articular surfaces (e. e.) of the subjacent Vertebre, a kind

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of junction specially adapted for rotatory motion. The spinous processes (d.) are short, and nearly horizontal, and a considerable quantity of soft substance being interposed between the bodies of the Vertebres, a very great degree of flexion and extension is admitted. The spinous hole (b.) in this division again becomes large and triangular, in which respect it resembles the Cervical: in that it was large on account of the great size of the spinal nervous cord; in this it is capacious to permit the branching of the same cord immediately prior to its termination.

The last Lumbar Vertebre is distinguished from the others by its immobility, the front edge of the lower surface of its body bending over the top of the body of the rump-bone, and its spinous process hooking down upon the spinal arch of that bone.

Thus far the description has had special reference to the motions of the several pieces of the Spine upon each other, but there is another point of view in which the Vertebres are to be considered, viz., as forming a pyramid of support, or rather a rod upon which the neck, chest, and belly are suspended. As might be expected, the base of this pyramid or rod, speaking in general terms, is the broader, and the apex the narrower. The pillar of support is specially formed by the bodies of the Vertebres, the base of which is the last Lumbar, and the tip the Second Cervical. Circumstances, however, exist which prevent the regular diminution of the column from below upwards without diminishing its strength. The opportunity of increasing its capacity, as may be needed, being allowed to the belly by its soft muscular walls on the sides and front, which are capable of extension, the bodies of the Lumbar Vertebres are very large, and much expanded laterally; still, however, they diminish from below upwards, so that the upper are much smaller than the lower Vertebres. In the Dorsal portion, however, the case is altered: this, as will be hereafter shown, forms part of the Chest, a cavity surrounded by bone, and from this cause incapable of extension beyond a certain point; the Vertebres are therefore required to be as small as possible to prevent their trenching on the cavity, regard being still had to the strength of the Spine, and accordingly their bodies are narrow laterally in comparison with the Lumbar, but in proportion to this dimension are more extended from before to behind. This lateral narrowing continues as high up as the fifth, from whence they again become wider and wider, but less extended from before to behind up to the first. This diminution of width, however, is of no material consequence, being compensated by the connexion of the ribs, which strengthens the Dorsal part of the Spine, although the vertebral bodies are diminished in size. Whilst, on the contrary, the upper members of the Dorsal Spine have the extent of their bodies increased, not only to strengthen them as fixed or nearly fixed points for the junction of the upper ribs, but also to afford a base for the support of the Cervical Vertebres, which are broad below, but narrow as they ascend to support the head, and to afford room for the muscles by which they are moved.

Of the Rump (*Uropygium*, Lat.; *das Kreuz*, Germ.; *le Croupe*, Fr.)

The remaining portion of the Spinal Column consists of two bones, the Rump-bone and the Tail-bone. By the former more especially the Lower Limbs are connected with the Spine through the intervention of a pair of bones, which, with the two forming the Rump, produce a bony cavity hereafter to be described.



The Rump-bone (*Os Sacrum*, Lat.; *die Kreuz-bein*, Germ.; *le Sacrum*, Fr.). (Fig. x.)

Placed immediately beneath the last Lumbar Vertebre is a large bone of a flattened pyramidal or wedge-like form, with its broad base (g.) above and its narrow tip (f.) below; it is concave from above downwards, and from side to side in front, and convex from above downwards behind. In the young subject it consists of five pieces, which, having the general form of vertebres, are called *false vertebres*, but in the adult state are united into a single bone. Their original separation is, however, still indicated by four slight and horizontal ridges, traversing the middle or body of the bone. On either side of the body are seen four apertures, by which nerves are transmitted, and corresponding to the holes formed by the approximation of the roots of the transverse processes in the true Vertebres. The transverse processes in this bone, however, being consolidated, a large articular or joint surface (c.) is produced on each of its sides, by which it is connected with the Hip-bones. The hinder surface has along its middle a sequence of little bony studs (d. d. d. d.) corresponding to the spinous processes of the Vertebres. The top of the body, called its base (g.), has a large plane oval surface, to connect it with the body of the last Lumbar Vertebre, and a pair of hollow articular processes (e. e.) to receive the corresponding processes of that Vertebre. The lower end of the body has a small oval articular surface for the Tail-bone. The spinal canal is continued down between the body and spinous processes, but varies in different individuals, being more or less open at the lower part from the deficiency of its hinder walls, and sometimes leaving even the whole canal open throughout like a narrow gutter. The Vertebral pieces are consolidated, and form thus a single bone, to afford a stronger connexion to the Hip-bones than if they remained separate. This subject must be again adverted to in speaking of the Basin or Pelvis, when also the applicability of its peculiar disposition and form will be better understood.

The Tail-bone (*Os Coccygis, seu Coccyx*, Lat.; *die Steiss-bein*, Germ.; *le Coccis*, Fr.) (Fig. xi.)

The Tail, though not appearing externally to the common covering of the body, as in most of the higher animals, exists in the human subject in the form of four or five small pieces, resembling transverse sections of the Rump-bone with its spinal arch cut off, and therefore no canal for the spinal cord is found. These always in the young, and most generally in the adult, exist as distinct portions, but occasionally are found united into a single bone, resembling a diminutive Rump-bone, the original divisions being indicated by three or four transversely indented lines. The upper piece (a. b.) has a pair of small elevated processes (a. a.) which connect its hind part more firmly to the Rump-bone, but neither of the other pieces (d. e. f.) have any process. The object effected by the permanent division of this bone, as is usually the case, will be noted in treating of the Basin or Pelvis.

*Of the Vertebral Joints* (Figs. xv. xvi. xvii.).

The connexion of the Vertebral pieces being with reference both to strength and mobility, is effected, inde-



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pendently of the muscles, which also tie them together, in three different ways: *first*, by a ligamento-cartilaginous substance between their bodies; *secondly*, by true ligamentous bands, some passing from one Vertebre to another, and others connected with all save one; and *thirdly*, by true joints, in which exist true joint or articular surfaces, covered with cartilage, and included in an investing capsular ligament, lined with synovial membrane, which also overspreads the articular cartilages.

1. All the Vertebres, below the first Cervical, have their bodies connected together by a fibro-cartilaginous structure, which from its position is called the Intervertebral Substance (a.) (*fibro-cartilago-intervertebralis*, Lat.; *der zwischenwirbelknorpel*, Germ.; *les fibro-cartilages*, Fr.). Each consists of a series of concentric bands, toughest and most resisting at the margin of the vertebral bodies, but looser and more yielding as they approach the centre, till at last they resolve into an almost half fluid mass. How this acts, is best illustrated by reference to the vertebral junction in Fishes. In these animals, as shown in the Essay on Zoology, p. 295, the body of each Vertebre is hollowed out into a fore and hind conical cavity, the points of which are opposed to each other in the centre of the body, but do not communicate; the margin of the base of each cone is connected by a ligamentous ring with the preceding and subsequent Vertebre, and thus a hollow double cone occurs between every two of these bones, in which is contained a watery fluid. This fluid being incompressible, and the bony cones no less so, it follows that whenever one cone is moved on the other, the ligamentous ring, which is alone yielding, is subjected to the pressure which the fluid makes in the opposite direction to that in which the bones are approximated; but the central part of the fluid remains nearly or entirely unchanged, whilst the rings of the cones may be rolling round upon each other, and therefore forms an incompressible though movable and infrangible centre, so long as the marginal ring remains unbroken. Now in the human subject exactly the same function is performed by the Intervertebral Substance; its marginal rings, from their elasticity, may be compressed or expanded, but the central and more fluid part retains its incompressibility; and accordingly, if the muscles or any other cause operate to incline the Vertebres to one side, whilst the central soft substance is displaced in that, yet it displaces the marginal rings on the opposite direction, and thus still remains as a pivot upon which one Vertebre moves or rather sways upon another. So soon, however, as the displacing cause ceases to operate, the natural elasticity of the marginal rings especially, and the disposition of the central soft part to resume its proper place, both tend to restore the natural vertical position of the Spinal Column.

In like manner, as the bodies of all the Vertebres, except the first, are connected by this fibro-cartilaginous structure, so are their arches by another peculiar kind of substance, which is called the Yellow Substance (g.) (*ligamenta subflava*, Lat.; *die gelbliche bänder*, Germ.; *les ligamens jaunes*, Fr.). Each piece consists of thick, short vertical fibres, of a yellow colour, and elastic, which pass from the lower edge of the arch of one to the upper edge of the arch of another Vertebre; their length depends upon the distance between the vertebral arches, they are therefore longer in the loins than many other parts of the Spine. Their use, however, throughout is the same; they strengthen the connexion of the Vertebres, assist in restoring the vertical position of the spine when it has been disturbed, and have material influence in preserving the erect posture of the trunk without violent muscular exertion.



2. The next kind of junction which the Spine presents is the mere colligation or tying together of its several pieces. To this purpose the two just-mentioned substances also serve, but there are other and true ligaments which perform this duty alone; such are, The Anterior Common Ligament (b.) (*ligamentum commune anterius*), which commences at the basilar process of the Occipital bone, passes down, connected with the front of the body of every Vertebre, and is finally spread out upon the front of the Rump-bone: it varies in breadth from half an inch to an inch, according to the size of the Vertebres, being narrowest in the neck and widest in the loins; but it is thickest where the Spine is weakest, viz., upon the upper Back Vertebres, and thus compensates for the seemingly deficient strength of that part. The Posterior Common Ligament (*ligamentum commune posterius*) commences by a fan-like expansion from the upper surface of the basilar process within the skull, passes through the great occipital hole, is attached to the tip of the pivot of the second Cervical Vertebre (which portion is sometimes described as distinct, and called the Perpendicular Ligament), then descends, expanding over the hind part of the bodies of all the Vertebres, and is ultimately lost on the back of the body of the Rump-bone. The margins of the bodies of all the Vertebres, except the first and second Cervical, are further connected by means of ligamentous fibres called Crucial Ligaments (*ligamenta cruciformia*), from their direction, which decussate upon the Intervertebral Substance, and are connected both with it and with the bodies of the Vertebres. Narrow bands of ligament pass also from one transverse process to another, and from one spinous process to another, which are called Intertransverse and Interspinous Ligaments (e.) (*ligamenta intertransversa*, and *interspinosa*).

3. The remaining junction of the Vertebres is by their joint or articular processes, which are alone, anatomically speaking, *true joints*. The opposing surfaces of these processes are covered each with a thin layer of cartilage, and invested in a close ligamentous collar or capsular ligament (*ligamenta capsularia*), lined with synovial membrane. These capsules, in all the vertebral joints below the second cervical, allow flexion and extension, lateral inclination, and a complication of all three; but between the second and first Vertebres the motion, from the nearly horizontal position of the articular surfaces, is only rotatory, and between the first Vertebre and the skull only slight flexion and extension, owing to the great depth of the sockets in the former for the latter bone.

The Ligaments already described are common to all the Vertebral pieces, but the motions between the second and first Neck Vertebres and the latter and the skull being different, inasmuch as they are performed by true joints, and the principal motion being horizontal, and performed between the two just named Vertebres, some ligaments are there found necessary for the performance and restriction of these motions, which are not required in the more confined movements of the other Vertebral pieces. They are, therefore, proper Ligaments of these Vertebres and of the occipital bone,

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 ano consist of three, besides that part of the Common Anterior Ligament, by some anatomists called the Perpendicular, and by them considered as one of the proper Ligaments.

It will be recollected that the pivot of the Second Neck Vertebra rises up into a hollow in front of the vertebral canal of the first Vertebre, produced by the scooping out of the back of the body of that Vertebre; in this the pivot is confined by means of a Transverse Ligament (*ligamentum Atlantis transversum*, Lat.), which, passing behind the root of that process, from one side of the Atlas to the other, completes a ring placed round the pivot, carrying with it the skull. The horizontal motion, however, thus performed, does not, when measured from point to point, exceed one-third of the circumference of a circle, being restricted by a pair of ligaments, viz. the Lateral (*ligamenta lateralia*, Lat.), which, originating from the sides of the pivot, ascend obliquely outwards, and are attached to the upper and inner edge of the occipital hole. The more extended motion by which the head describes a half circle upon the shoulders is effected by the movement of the Neck Vertebres upon each other.

*General Observations relating to the Spine.*

*As to Form.*—The Spine in different positions exhibits very different appearances. In front it assumes, from the Rump-bone upwards to the Atlas, the form of a tall pyramid, the base of which is the last Lumbar, and the apex the second Cervical Vertebre. Closer observation, however, will show that it really consists of three pyramids, the lower two connected by their tips and the upper two by their bases. From the last Lumbar to the fourth or fifth Dorsal, the bodies of the Vertebres gradually diminish, and here is the top of the first pyramid; from this point, forming the top of the second pyramid, the bodies gradually widen up to the last Cervical, which forms its base, and the base also of the third pyramid, the top of which occurs at the second Cervical Vertebre. The diminution of the width of the bodies of the Dorsal Vertebres increases the capacity of the Chest.

A side view of the Spine shows it, not as might be at first expected, upright, but of an undulating form from before to behind; consequently, the perpendicular mesial line, which passing through the basilar process of the occipital bone drops between the feet, only touches it between the fourth and fifth Neck Vertebres, and between the second and fourth Loin Vertebres. At these points two forward curves are produced, and above and below them the Spine recedes, the greatest recession being opposite the middle of the Rump-bone, which is two inches behind the mesial line, whilst at the fourth Back Vertebre it is an inch behind, and opposite the Atlas half an inch. The use of these recessions is to increase the capacity of the cavities opposite which they are, and also to assist in preserving the equipoise of the trunk, as will be hereafter noticed. In this view of the Spine may also be observed the relative height of the intervertebral substance throughout the whole of the Vertebral column below the Neck: this is greatest in the Loins, where is the greatest quantity of motion, both flexion, extension, and swaying to either side being performed in consequence of the small size of the transverse and the distance of the spinous processes from each other. The direction of the transverse processes is also worthy of notice: in the Neck and Loins they stand directly outwards, but  in the Back incline considerably backwards, to increase the capacity of the Chest. In front of them a series of holes are seen, one between every two Vertebres, by which the nerves pass out from the Vertebral Canal. Behind the transverse processes, on each side, is a hollow corresponding to the curves of the Spine, and bounded by the spinous processes, which in the Neck and Loins pass directly backwards, are quite distinct from each other, and therefore allow free rotation of one Vertebre upon another, so far as they are concerned; but in the Back they lap over one another like a series of tiles, and prevent any other motion than slight flexion and extension.

The hind view, as to form, exhibits little more than is seen in front; the spinous processes occupy the mesial line, and the principal points to be noted are the forked forms of those in the Neck, the sharp upper edges of those in the Back, which terminate almost in points, and the depth of those in the Loins. In the Back, the arches of the Vertebres overlap so completely that they resemble scales, and no space exists between them, in which respect they differ widely from the lumbar arches, which are short, nearly vertical, and far apart from each other, so that the Vertebral Canal is open between them; the same also occurs in the Cervical portion of the Spine, but the Arches are less widely apart. Below the last Loin Vertebre the back of the Rump-bone is seen, with its imperfect spinous processes, and sometimes the arch is entirely deficient; on either side a row of small holes for the transmission of nerves. The Tail-bone is seen below it, curving forwards.

The last circumstance to be adverted to in the Spine, with reference to its form as a whole, is the Spinal or Vertebral Canal (*canalis vertebralis, seu spinalis*, Lat.; *der rückenmarks-kanal*, Germ.; *le canal vertébral*, Fr.). This is produced by the sequence of the spinal holes, and the yellow substance which connects the vertebral arches. Its course follows the several curves of the Spine. Its form is triangular, with the base towards the bodies, and the point towards the spinous processes of the Vertebres. It varies considerably in size, as might be expected from the varying size of the Spinal Cord of Nervous Matter, which it contains and protects; in the Neck, its greatest transverse diameter measures three-quarters of an inch, in the Back about seven-twelfths, in the Loins rather less, and in the Rump-bone much less; its extent from before to behind is in the Neck half an inch, and in the Back and Loins seven-twelfths; whilst its transverse diameter in the Neck is three-quarters of an inch, and in the other regions only a little more than half an inch. On either side, and behind the bodies of the Vertebres, are pairs of holes through which the nerves pass from the Canal; of these there are seven to the Neck, twelve to the Back, five to the Loins, and five to the Rump-bone.

*As to Mechanism.*—The mechanical structure of the Spine must be considered under five points of view: *first*, in reference to self-support; *secondly*, as supporting the Trunk and Head; *thirdly*, as protecting the Spinal Cord; *fourthly*, in reference to the motions it performs upon itself; and *fifthly*, as being the fixed point either to be moved by the locomotive organs, or from which the prehensile organs commence the performance of their functions.

a. *Self-support.*—It may seem almost paradoxical to state that the undulating form of the Spine is the best

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suited for its support; but when shall hereafter be pointed out the complicated offices it has to perform, this will prove to be the case, and will present one of the many beautiful examples of the Infinite Wisdom with which the human body has been constructed. The subject, however, cannot be fully carried out till we have further examined and are more fully acquainted with other mechanical parts of the body, not only as relating to the cavities of which the trunk consists, but also with reference to the muscular forces which are constantly operating upon the Spine. All that can be here adverted to is, that the bodies of all the Vertebres are kept a certain distance apart by the intervertebral substance, everywhere highly elastic, but most so at the margin; whilst towards the centre it assumes a half fluid form, and, being contained in an elastic ring, forms a hydrostatic pivot, which, when compressed by the weight of the head and upper limbs, bulges out the elastic ring to a certain extent, but is restricted by the crucial ligaments which pass from the margin of the body of one to that of another Vertebre; and if the general vertical position of the Spine be disturbed by any agent, this half fluid mass, not diminished in quantity, but still occupying the same quantum of space, though not the same actual space as if compressed on one side, thrusts out the elastic ring in the opposite direction, to find room for itself. *Procession* and *recession*, or the falling forwards or backwards of the Spine, are prevented; the former immediately by the posterior common ligament which connects the hind part of the bodies of all the Vertebres, and mediately by the ligamentous junction of the spinous processes, which act like the rod of a steelyard, to the extremity of which a very slight weight being appended, a very heavy weight upon the short limb is easily counterbalanced; the latter, recession, directly by the anterior common ligament which connects the front of the bodies of all the Vertebres, and indirectly in the Neck by the weight of the head, the principal part of which is before the Vertebral Column, in the Back by the overlapping of its spinous processes, and in the Loins by the overhanging forwards of the Back upon the receding Lumbar Vertebres. Now, though the Spine, as far as hitherto noticed, is, by the means already referred to, preserved in its vertical position as regards its several pieces, yet taken as a whole it is always disposed to fall forwards, although its base, as will be hereafter seen, is placed far behind the lower limbs which support the trunk: this arises from the weight of the greater part of the head, and that of the chest and belly being before it. This tendency is necessary to facilitate progression; it is not, however, so great as might at first be imagined, and is counterbalanced by the large size and disposition of the gluteal muscles peculiar to man. *Lateral inclination, or swaying from side to side*, is prevented in the Neck and Loins by muscles, which in those parts brace the Spine upright, as a ship's masts are braced up by the shrouds; and in the Back, by the connexion of the ribs to the bodies and transverse processes of the Vertebres, which almost entirely preclude lateral motion.

b. *As supporting the Trunk and Head.*—The Vertebres being connected and braced up, as already stated, there is no difficulty in understanding that, when steadied by muscles, the Spine is fully competent to sustain any weight, as the chest and belly, which may be appended to it in front, or placed, like the head, upon its top.

c. *As protecting the Spinal Cord.*—The firm connexion of the numerous pieces of which the Spine is composed, allowing but very little motion of any kind between any two pieces (excepting between the Atlas and Axis), although when acting together very considerable movements are performed, indicates the great care with which Nature has provided against injury to the Spinal Cord, commensurate with the important functions which this portion of the Nervous System has to perform in the Animal Œconomy. It might be supposed that the Spine would have been stronger had it consisted of but one long bony cylinder; had it been so, however, the necessary as well as graceful motions of the Trunk could not have been performed, and it would actually have been less strong and less protection to the Spinal Cord than as at present composed; for if a cylinder of such length as the Spine is, and with walls only of such thickness as could be made by the quantity of bone forming the Spine, received a blow, it would readily break, and in breaking tear through the Spinal Cord. Whereas, on the contrary, the bony cylinder being divided into so many pieces as it is, would yield to a certain extent, and distribute throughout the whole chain any blow which should be received upon it, and so diminish the liability to fracture and the danger of injuring the Spinal Cord. Also as regards the ligamentous connexions, these do not diminish the strength of the Spine but rather increase it, for they not only deaden the shock of any blow received by interposing a soft substance between the bones, but are actually so strong, that when a violent blow is struck upon the Spine, the bones themselves are fractured rather than any rupture of the ligaments, particularly of the intervertebral substance, should take place, as is continually seen in Fractures of the Spine.

d. *In reference to the Motions it performs upon itself.*—In consequence of the form and disposition of the articular processes, and the shortness of their connecting ligaments, the motions performed between any two pieces of the Spine are very slight, with the single exception of one kind of motion between the two uppermost Neck Vertebres. Taken together, however, they are very considerable and very varied, not only in kind, but also as to extent, and as to the mechanism by which they are performed, in the several regions of the Spine. Thus the Neck and Loins, though performing the same kind of motion, differ in the apparatus by which it is effected, whilst the mechanism of the Back is such as almost to preclude motion of any kind.

The simple motions performed by the Spine upon itself are flexion, extension, and lateral inclination; but all three can be successively combined, and thus produce a compound movement called circumduction, commonly though not properly expressed by the term "rolling the body round." If the whole Spine participate in either of these motions, the base from which they commence is the Rump-bone, which is steadied by its connexion with the hip-bones, and the part which is most displaced from its natural position is the upper end of the Vertebral Column. But portions only of the Spine may act, and it is therefore right to consider the motions which each region is capable of performing.

a. *Motions of the Neck.*—In this division of the Spine the motions are the most extensive and the most varied, and effected by two different kinds of mechanism.

1st. The Atlas and Axis are not connected by interver-

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tebral substance, but instead of a body the former has a circular hole completed by the transverse ligament, into which is received the pivot-like process of the latter, and the opposing articular surfaces of both being nearly horizontal, and placed very far forward even upon the top of the body of the Axis, the Atlas travels horizontally upon the latter and around the pivot. This horizontal motion, however, does not exceed an arc of the sixth of a circle, being limited by the lateral ligaments attached to the top of the pivot, and the edge of the great occipital hole, and from this function not inaptly called *moderating ligaments* by some anatomists. The motion is very easily and very briskly performed in consequence of the great length of the transverse processes, which act like the bars of a capstan.

2nd. The remaining Neck Vertebres have the same kind of connexion as the other pieces of the Spine, but modified to increase their mobility. This is effected by the greater elasticity of the intervertebral substance; the quantity of which is, however, less than in either of the other Vertebral regions, admitting the extended play between the vertebral bodies which arises out of the double concave and double slightly convex surfaces which their opposing extremities possess; whilst the looseness of the ligamentous capsules of the articular processes allow greater extent of play, and the shortness of the transverse do not interfere with it. The consequence is, that between every two of these there is greater motion, flexion, extension, and lateral inclination, than between many other Vertebres, and that circumduction is also much more extensive. Besides these there is also a turning of the Neck as it were upon a central pivot from side to side, by which, if the rotatory motion of the Atlas be included, the head is able to describe an arc measuring one-third of a circle.

β. *Motions of the Back.*—As firmness and strength are the great points towards which the mechanism of this region of the Spine is directed, the motions which occur between its several pieces are very trivial. They can indeed bend a little forwards, backwards, or to either side; but to any extent flexion and lateral inclination are prevented by the junction of the ribs, and extension by the overlapping of the vertebral arches and spinous processes.

γ. *Motions of the Loins.*—The quantity of motion here performed is only less than in the Neck; the great distance apart of the bodies and spines, and the shortness of the transverse processes of these Vertebres, admitting of great freedom and extent of motion. The flatness of the bodies of these bones, combined with their free play, would render the Spine at this part extremely weak, and its pieces very liable to displacement, were it not for the beautiful contrivance of the articular processess, which, instead of overlapping or resting against each other, as in the Neck and Back, are actually pegged into one another, the solid half-cylindrical lower processes being received into corresponding concavities on the upper end of the subjacent bone, thus forming a double row of ties, whilst their rounded form allows of slight horizontal rotation upon each other.

ε. *As being the fixed part of the body either to be moved by the locomotive organs, or from which the prehensile organs commence the performance of their functions.*—The former of these purposes is effected by the junction of the Spine with the pelvis or basin, which intermediately connects it with the lower limbs; whilst the latter is brought about by the muscles attached to it keeping the Spine steady in any position required for the advantageous employment of the prehensile organs, so that it forms a resistance upon which, or from which, the muscles moving the upper limbs can act.

## 2.—OF THE HEAD.

*Caput*, Lat.; *der Kopf*, Germ.; *la Tête*, Fr.

The Head of the human subject is remarkably distinguished from that of all other Vertebrate Animals by the great size of the brain-case or skull, by the plane of the face being parallel to that of the vertical spine, by the non-projection of the front of the mouth, by the absence of incisive bones, and by the prominence of the chin. It is divided into the skull and face.

### Of the Skull (*Cranium*, Lat.; *der Schadel*, Germ.; *la Crâne*, Fr.) (Anat. Pl. V., fig. I. to VI.)

Consists of four single bones, the occipital, sphenoid, ethmoid and frontal, and two pairs, the temporal and parietal.

### 1. The Occipital Bone (*Os Occipitis*, Lat.; *die Hinterhaupts-bein*, Germ.; *l'Occipital*, Fr.) (Fig. I.)

Is situated at the back and under part of the Skull, forming a large portion of the Hind-head and base of the Skull, and transmits the weight of the whole Head to the Spine. It is concave from above downwards, and from side to side in front, and convex in the same directions behind. It is of an hexagonal figure, one sharp angle above and behind, the *occipital* (a.); another before and below, truncated, the *sphenoidal* (b.); and on each side two,—the upper pair the *parietal* (c. c.), and the lower the *temporal* angles (d. d.). Between these angles the upper two edges are the *parietal* (a. c.), the middle two the *temporal* (c. d.), and the lower two the *basilar* (d. b.). Internally, at the bottom of the bone, is the *great occipital hole* (e.), of an oval form, with its long diameter from before to behind; in front of this rises up the wedge-like process, the *basilar*, which is broad below and narrowing above where it joins to the sphenoid bone, and hollowed from side to side for the lodgment of the annular tubercle of the Brain or great commissure of the Cerebellum, and has a small groove on each of its sides for the inferior petrosal sinuses. Behind the great hole the bone rises and expands considerably, forming four cavities,—the lower two for the lobes of the Cerebellum and the upper two for the posterior lobes of the Cerebrum, and these are divided by a *crucial ridge* (f. f.), the horizontal limb of which gives attachment to the tentorium and lodgment to the lateral sinuses, and the vertical limb above the horizontal receives in it the longitudinal sinus, and gives connexion to the greater falx of the dura mater, and below the horizontal is slightly grooved for the occipital sinus, and has the lesser falx attached to it: upon the upper surface of the temporal angles are grooves for part of each lateral sinus, as they descend to the *great lacerated basal holes*, part of which are formed by notches in the basilar edges. Externally the bone is very smooth above the *great transverse ridge* (h. h.), which passes across in a curving form from one parietal angle to the other, and has in its centre a prominence called the *occipital protuberance* (i.), from which descends to the hind part of the great hole a

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sharp low ridge called the *occipital spine* (g.), crossed about an inch below the protuberance by the *less transverse ridge* (i. i.), which curves from one temporal angle to the other, and having between it and the great hole two *pits* for muscular insertion. On each side of the anterior half of the great hole are placed the *condyloid processes* (j. j.), by which the skull articulates with the spine. These are convex from behind to before, deepest in front, and face outwards and downwards; and extending outwards from each is a *ridge* terminating in the temporal angle on each side for muscular attachment; in front of the great hole is seen the under surface of the basilar process.

In the Occipital Bone there are one single and two pairs of holes proper to it.

The Great hole, already mentioned.

The Anterior Condyloid holes before the Condyles, and running into the Lacerated holes.

The Posterior Condyloid holes behind the Condyles, and often only one.

Besides which are found a pair of notches, in the basilar edges, part of

The Posterior Lacerated holes, which are completed by the Temporal Bone.

2 & 3. The Temporal Bones (*Ossa Temporum*, Lat.; *die Schläfe-beine*, Germ.; *les Temporaux*, Fr.) (Fig. II.).

The sides and under part of the Skull, from the temporal angles of the Occipital, and reaching rather before the plane of the Sphenoidal angle of the same bone, are formed by the Temporal Bones, which take their name from being placed in the back part of the Temples of the Head.

The Temple-bone is of very irregular shape, consisting of three distinct parts: the knobby portion, which joins the temporal edge of the Occipital, and is behind the great external auditory opening; the scaly piece, which rises above and before the same aperture, and forms together with the former portion a large part of the side of the Skull; and the triangular piece, of rocky hardness, which runs from the auditory opening inwards and forwards, and is connected by its hind edge with the basilar edge of the Occipital Bone. The *Mamillary Portion* (A.) is named from its large *nipple-like process* (a.), which may be felt like a large knob behind the ear in the living subject: upon its point is a groove for the passage of the occipital artery; on the inner side of its root is the deep *digastric pit*; and behind it is the *mastoid hole*: this process is hollowed out within the Skull, forming a broad deep groove to receive the termination of the lateral sinus. The two tables forming the walls of this portion are far separated, and filled up with numerous cavities containing air, called the *mastoid cells*, and communicating with the internal ear. The upper edge of this portion is nearly horizontal, and deeply toothed. 2. The *Squamous Portion* (B.), so called from its principal part consisting of a large flat scale-like or *squamous plate* (e.), which rises above and before the auditory aperture; it is very smooth on the outer surface, but within irregular with the finger-marks and nipple-like elevations; nearly the whole of its circumference, except at the lower part, is beveiled from without inwards and downwords. From the under, outer, and back part of the Squamous Portion projects outwords and forwards the *zygomatic process* (d.), which terminates in the toothed *malar process* (e.); between the root of the former process and the squamous plate is a smooth surface or *pulley*, over which the temporal muscle plays, and below it is the *glenoid* or *articular cavity* to receive the condyle of the lower jaw, bounded in front by the *articular eminence*, which terminates externally at the *tubercle*. 3. The *Petrous Portion* (C.), of almost rocky hardness, has a prismatic shape, running inwards and forwards from between the Squamous and Mamillary Portions its *upper angle* (e.) is most regular, and has an indistinct groove upon it for the lodgment of the superior petrosal sinus; near its inner extremity is a slight notch, over which the trigeminal nerve passes, and towards the outer an *elevation*, which marks the top of the vertical semicircular canal: in the anterior inferior angle is the bony part of the *Eustachian Tube*, and above it part of the *carotid canal*; in the posterior inferior angle, which is very irregular, there is a deep *notch* completing the *posterior lacerated hole*, which is divided into two by the little jutting *jugular process*, and to its inner side is a conical cavity in which the *aqueduct of the cochlea* terminates: in the front face of the prism is seen the *trigeminal groove*, continued from the notch just mentioned, below it part of the *anterior lacerated hole*, and extending from it outwards and upwards the *unnamed canal*, to terminate in the *unnamed hole*, to the outer side of which is the *front leg of the vertical semicircular canal*; in the hind face, at its inner edge, a slight *hollow*, completing with the basilar process of the occipital bone the groove for the inferior petrosal sinus; to its outer side, the large *internal auditory hole*, and further out the aperture of the *aqueduct of the vestibule*, covered by a plate of bone; in the base or under surface is the *jugular pit*, resembling the cavity of a thimble, into which the jugular vein is received as it joins the lateral sinus (this is usually found only in one Temporal Bone); to its outer side is the long *styloid process* (f.), surrounded by its *vaginal process*, and between it and the digastric pit is the *stylomastoid hole*, to the front of which is the *auditory process*, forming the floor of the *external auditory passage*, which terminates externally in the *external auditory hole*, between the Squamous and Mamillary portions.

In this Bone there are ten holes, of which have been described already—

The Mastoid, Unnamed, Stylomastoid, Internal and External Auditory holes, the terminations of the Aqueducts of the Cochlea and Vestibule, and of the Eustachian Tube. The others are—

The Glenoid hole in the Glenoid cavity, and

The Carotid hole in the base of the prism.

By its junction with the Occipital bone behind, it completes

The Posterior Lacerated hole: and by joining with the Sphenoid bone before,

The Anterior Lacerated hole and

The Internal Carotid hole.

Besides the parts already observed, the Petrous Portion of this bone contains the whole Internal Organ of Hearing, the description of which will be given in treating of the Organs of the Senses.

4 & 5. The Parietal Bones (*Ossa Parietalia*, seu *Ossa Bregmatis*, Lat.; *die Scheitel-beine*, oder *Seitenwandbeine*, Germ.; *les Pariétaux*, Fr.) (Fig. III.)

This pair of bones are situated in front of the Occipital, above and projecting a little in front of the

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Temporal bones, and form the vault of the Skull, to which the names *vertex*, *sinciput*, or *summit* have been applied.

The Parietal Bone is of a quadrangular figure, convex from above downwards, and from before to behind; its anterior or *frontal* (a.), superior or *parietal* (b.), and posterior or *occipital* (c.) edges are all straight and serrated, or toothed like a saw; its lower or *temporal* (d.) edge, about an inch behind the frontal, assumes a curved form with the concavity downwards, and this curve is bevelled from without to within where received within the bevelled edge of the Temporal bone; consequently, though the one overlaps the other, there is no greater thickness of the skull at this than at any other part; the anterior upper or *frontal* (e.), and the posterior upper or *occipital* (f.) *angles* are right angles; the anterior lower or *sphenoidal* (g.), and the posterior lower or *temporal* (h.) *angles* are truncated. Externally, the bone is smooth, excepting the indistinct curved *temporal ridge*, which, beginning from the middle of the frontal edge, runs backwards and descends into the temporal angle; a projection just above the middle of this ridge indicates the widest part of the skull. Within, the bone is marked by the mamillary eminences and finger-pits, and narrow *branching grooves* point out the ramifications of the middle meningeal artery, the trunk of which is seen in a *vertical groove* on the sphenoidal angle; a *horizontal groove* is observed on the temporal angle for part of the lateral sinus; upon the side of the parietal edge is part of a *longitudinal groove* (i.), completed by the junction of the bone with its fellow for the longitudinal sinus; and to the outer side of this some *pits* for the Pacchionic glands.

In this bone there is but one, the Parietal hole, near the parietal edge, and generally only in one of the bones.

6. The Sphenoid Bone (*Os Sphenoides*, Lat.; *der Keil-bein*, Germ.; *le Sphénoïde*, Fr.) (Fig. IV.)

Is placed in front of the Occipital and Temporal bones, forming with the latter the cavities in which the middle lobes of the Cerebrum rest. It is usually said to lock or wedge together all the bones of the Skull, whence is derived its name. It serves, however, the much more important office of connecting the Skull with the Face, being joined with all the bones of the latter, except the Nasal, Lachrymal, and Turbinated, and the Lower Jaw. It somewhat resembles an animal with expanded wings and depending legs; hence has been compared by some anatomists to a bat, and by others to a wasp, but the similarity is not very obvious. It is divided, for convenience of description, into five parts,—the body, two pterygoid, and two temporal portions.

The Body (f.) occupies the middle of the bone, and consists of two *sphenoidal cells*, divided by a middle bony partition; it is placed immediately in front of the basilar process of the Occipital bone, to which it joins by the rough *basilar process* (b.) on its hind part, on either side of which is seen a notch, completing with the temporal bone the *internal carotid hole*; the top of the body is bounded behind by the square *posterior clinoid process*, and before by the *olive-shaped process* (c.), which gives to the hollow between them a saddle-like form, whence it is called the *Turkish saddle*; projecting backwards over the front of the latter are the two little *anterior clinoid processes*, having at their roots the *optic holes*; and extending outwards from these, gradually becoming more slender, and terminating each in a point, are the *transverse spinous processes* (d. d.), sometimes also called the *lesser wings*, or the *Ingrassian processes*, after the anatomist who particularly described them; upon the middle of the front of the body is the *ethmoidal spine* and *crest* (c. a.), the latter of which, descending vertically, has on each side the *openings* of the sphenoidal sinuses; the crest terminates below in the *azygos* or *single process* (e.), a short sharp spur of bone, on either side of which a triangular plate is sometimes called the *triangular bone* (f.), which bounds the top of the *spheno-palatine holes*.

From the under part of the sides of the body descend—

The Pterygoid Portions (l. g.), although so named, correspond to the legs of the flying animal. Each of these are divided posteriorly into two plates by the vertical gutter-like *pterygoid pit*, which at the lower part terminates in the *pterygo-palatine fissure*, by which they are entirely divided; the inner or *nasal plate* (g.) is long, narrow, and terminates in a hook-like or *hamular process* (h.), over which a muscle of the palate plays; the outer or *muscular plate* (i.) is short, wide from before to behind, and turned much outwards: part of the *pterygo-palatine canal* is seen on the front of this portion, into which the *pterygoid holes* run above, and below a rough surface.

The Temporal Portions (j. k. l.) extend from between the body and pterygoid portion on each side outwards for some distance, forming the floor of the middle cavities of the Skull, and terminating behind each in the *spinous process* (j. j.), which is received in a triangular cleft between the petrous and squamous portions of the Temporal bone, and has upon its extreme back and under part the little *styliform process*. Having formed this floor, it ascends vertically on the side of the Skull, and assumes the name of *temporal plate* (k. k.), which forms part of the temporal pit, is joined behind to the squamous plate of the Temporal, and above to the Sphenoidal angle of the Parietal bone: in front of the middle cerebral cavity it also rises vertically, facing forwards and inwards, and, bounding the back and outer part of the orbit, acquires the name of *orbital plate* (l.), between the upper edge of which and the transverse spinous process is the *superior lacerated orbital hole*, whilst its lower edge forms part of the *inferior lacerated orbital hole*. The apertures in this bone are seven pairs, of which the following have been noticed:—

The Optic, Superior Lacerated Orbital, Pterygoid holes, and the openings of the Sphenoidal Sinus. The others are—

The Round holes behind the Superior Lacerated,

The Oval holes behind the last, and

The Spinous holes in the spinous processes.

By its junction with the Temporal bone it completes—

The Internal Carotid and the Anterior Lacerated Basal holes; with the Palate-bone it forms

The Spheno-palatine hole; and with that and the Superior Maxillary bone,

The Inferior Lacerated Orbital holes.

7. The Ethmoid Bone (*Os Ethmoides*, Lat.; *die Siebbein*, Germ.; *l'Ethmoïde*, Fr.) (Fig. V.)

Is situated at the bottom of the Skull in front of the body of the Sphenoid bone, between the two Orbits, forming their inner boundaries and the upper part of the Nose. Its upper surface being perforated by nu-



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merous holes like those of a colander or sieve, it has acquired the name Ethmoid Bone.

It is of an oblong square form, consisting of numerous bony convolutions, some of which coalesce and form the *ethmoidal cells* (a. a.), which are divided into *anterior* and *posterior*, and others are unconnected, the middle two of which, being very long, are called *turbinated plates*; these cells are bounded on each side by the smooth *flat plates* forming the inner boundaries of the orbits, but which are deficient in front; the upper surface of the bone which forms part of the floor of the Skull is the *cribriform or sieve-like plate* (b. b.), full of very minute holes, which are separated into two sets by an elevated process commencing from the hinder margin and gradually increasing in depth in front, and from its figure called the *cock's-comb* (c.); opposite to which, from the under surface of the cribriform plate descends the *nasal plate* (d.), dividing the ethmoidal cells into two lateral sets; this plate is thick behind to join the ethmoidal process of the Sphenoid bone, then behind and below for the Vomer, thick below and before to receive the septal cartilage of the nostrils, and thick before and above to join the Frontal bone.

Besides the Sieve-holes, there are,—

The Posterior Ethmoidal holes leading to the corresponding sinuses; and parts of

The Anterior Ethmoidal holes, and of

The Internal Orbital holes.

8. The Frontal Bone (*Os Frontis*, Lat.; *die Stirn-bein*, Germ.; *le Frontal*, Fr.) (Fig. VI.)

Occupies the front of the Skull, and forms the Forehead; it is placed before the Parietal bones above and on the sides, before the transverse spinous plates of the Sphenoid, around the sides and front of the Ethmoid bone, and forms the upper parts or vaults of the Orbits. It is usually compared to a clam-shell, the hinge part of which is below and behind, and the convex span of the shell facing forwards.

The bone is naturally divided into two parts by the *ridges* (a. a.) which support the eyebrows, situated at the lower and front part of the bone, and called the *supraciliary*, with a *notch* or *hole* in each: these are arched from side to side, and become more distinct towards the outer part of the orbits, where they terminate in the *external angular processes* (b. b.). On the inner side of the orbits they terminate also in other less defined *processes*, the *internal angular* (c. c.), which latter are separated from each other by a third indented concave surface called the *nasal process*, from the middle of which projects forwards, like the prow of an ancient galley, the *nasal spine* (d.). Behind the nasal process, in the under horizontal portion of the bone, is an oblong square aperture, the *ethmoidal notch*, which receives the Ethmoid bone, and on each side of this are the *orbital plates* (f. f.), of a triangular form, the bases running into the supraciliary ridges, and concave from side to side, forming the vaults of the orbits; some little apertures, the *frontal holes*, are sometimes here noticed, and occasionally near the inner angular process a little stud of bone serving as the pulley of a tendon; between the inner edge of each orbital plate and the ethmoidal notch are a row of cavities, part of the *frontal sinuses* (g. g.), which are perfected by resting on the edges of the Ethmoid bone; on the outer side, near the external angle, is a *hollow* for the lachrymal gland. The upper surface of the bone rises upwards and curves backwards till it joins the frontal edges of the Parietal bones; in front it sometimes, but not always, exhibits a *middle ridge* passing upwards and backwards from the nasal process, a little above which, and extending outwards, are the *prominences* marking the situation of the larger frontal sinuses, and varying in distinctness in different persons; above, and to the outer sides of these, are distinct *prominences* marking the *centres* of ossification of the two portions composing the bone in the young subject; immediately behind the outer angular process on each side is a depression forming the front of the temporal pit, bounded above by the curving of the *temporal ridge*, which is continued from the Parietal bone into the external angular process; on the back surface of this portion, immediately behind the nasal process, is the *blind hole*, and before it commences the *frontal spine*, which, rising up about an inch, divides into two, forming a *groove* which continues up to the groove formed by the junction of the parietal bones, and completes the hollow for the longitudinal sinus. The posterior margin of this bone, as low as the temporal ridges, is serrated and bevelled from behind forwards, but below the ridge from before backwards.

The apertures in this bone are—

The Blind hole,

The Supraciliary holes,

The Frontal holes,

The openings of the Frontal Sinuses. Besides which are formed

The Anterior and Posterior Internal Orbital holes, by the junction of this bone with the upper margin of the Ethmoid.

Of the Face (*Facies*, Lat.; *das Gesicht*, Germ.; *la Face*, Fr.) (Anat. Pl. V., fig. VII. to XIV.).

Consists of six pairs, the Nasal, Superior Maxillary, Lachrymal, Malar, Palatine, and Turbinated Bones, and two single ones, the Ploughshare bone, and Inferior Maxillary Bone.

1 & 2. The Nasal Bones (*Ossa Nasi*, Lat.; *die Nasenbeine*, Germ; *les Os du Nez*, Fr.) (Fig. VIII.)

Are a pair of small bones situated immediately below the middle of the nasal process of the Frontal bone, and forming the Bridge of the Nose.

Each Nasal Bone is fan-shaped; thick and deeply indented above where joining with the Frontal bone, but below very thin where connected with the cartilages of the Nose; its inner anterior edge is straight where joining its fellow, thick above and thin below; and its outer posterior edge grooved where connected with the Superior Maxillary bone; it is slightly hollowed from above downwards, and convex from before to behind externally, and concave in both directions within.

3 & 4. The Superior Maxillary Bones (*Ossa Maxillaria Superiora*, Lat.; *die Oberkiefer-beine*, Germ.; *les Os Maxillaires Supérieurs, ou Sus-Maxillaires*, Fr.), (Fig. VII.)

Are the largest pair of bones in the Face: they are united, form the Upper Jaw, the greater part of the bony Palate, the under and lateral parts of the Nose, and the floors of the Orbits.

The *body* of the Superior Maxillary Bone consists of a large cavity, called the *maxillary cavern*, the inner

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wall of which, forming the *nasal plate* of the bone, has in it an aperture called the *maxillary hole;* on the outer side the body is convex from before to behind, and terminates at the hind part in a fulness called the *tuberosity* (h.); from the outer upper part of the body projects a rough indented oblique surface, called the *malar process* (a.), below and to the inner side of which is a depression called the *infra-orbitar pit* (c.), and in it the *infra-orbitar hole;* on the inner, upper, and fore part, a pyramidal *nasal process* (d.) rises up to the inner angular and nasal process of the Frontal bone, with which it joins above, and by its anterior edge with the Nasal bone; on its inner surface is a ridge for the connexion of the Turbinated bone, and behind it a hollow forming part of the *lachrymal pit* and *nasal duct;* below this process is a large notch, completing with that in the opposite bone and with the Nasal bones the anterior opening of the Nostrils; extending inwards from the lower part of the nasal plate, the *palatine process* passes to join its fellow, forming with it part of the *nasal crest* above and the *palatine spine* below, and the fore part of the bony Palate; the outer lower margin of the bone is deepened by the *alveolar process* (e.), consisting of an inner and outer plate connected by transverse plates called the *alveolar plates*, which divide the groove into *alveolar cavities* for eight teeth in each bone, of which the sixth from the front communicates with the maxillary cavern; the upper surface of the bone, forming the floor of the orbit, is called its *orbitar plate* (f.), joining on the inner side the lower margin of the flat plate of the Ethmoid bone, and on the outside forming part of the *inferior lacerated orbitar hole.*

The holes in this bone already mentioned are—

The Infra-Orbitar,

The Maxillary,

The Anterior opening of the Nostrils,

The opening in the sixth alveolar cavity,

The Incisive hole in the front of the palatine process, running into

The Incisive duct, formed by the junction of both bones,

The Nasal duct, partly formed by this bone, and also

The Inferior Lacerated Orbitar hole.

5 & 6. The Lachrymal Bones (*Ossa Lachrymalia*, Lat.; *die Thränen-beine*, Germ.; *les Os Unguis, ou Lacrymaux*, Fr.) (Fig. IX.)

Are a pair of delicate bones, nearly as thin as paper, interposed between the nasal process of the Superior Maxillary and the flat plate of the Ethmoid bone, and covering those cells of the latter bone which are not covered by its flat plate.

The form of each bone is an oblong square; its inner surface is called its *ethmoidal plate;* its outer surface is divided into two by a vertical ridge, which terminates below in a kind of hook: the hinder portion, or *orbitar plate* (b.), is the shorter and wider; the front, or *lachrymal plate* (a.), is the longer and narrower, and completes with the Superior Maxillary bone the pit for the lachrymal sac. It joins the Ethmoid behind, the Frontal above, the Superior Maxillary before and below, and the Turbinated at its extreme lowest point.

7 & 8. The Malar or Cheek Bones (*Ossa Malarum*, Lat.; *die Jock-beine*, Germ.; *les Os des Pommettes*, Fr.) (Fig. X.)

Are situated on the outer under parts of the Orbits, below each outer angular process of the Frontal, and above the malar process of the Superior Maxillary bone.



It is of an irregular figure, has its outer surface convex from before backwards, where it terminates in the *zygomatic process* (a.), by which it joins the same process of the Temporal bone, and completes the *zygomatic arch*, within which the temporal muscle plays; its inner under surface is very oblique, deeply indented, forming the *maxillary process* (b.), to join with the Superior Maxillary bone, and bounded by the *inferior orbitar process* (c.); the bone curves upwards and outwards to form the *superior orbitar process* (d.), by which it is connected with the outer angular process of the Frontal bone, and from behind passes backwards the *internal orbitar process* (e.), forming the outer under part of the orbit, and with the Superior Maxillary, Sphenoid, and Palatine bones completing the inferior *lacerated orbitar hole:* the back of the bone forms part of the *temporal pit* (g.).

There is one hole proper to this bone, the Malar hole, which penetrates its anterior surface.

9 & 10. The Palatine Bones (*Ossa Palati*, Lat.; *die Gaumen-beine*, Germ.; *les Os Palatins*, Fr.) (Fig. XI.)

Are situated in front of the pterygoid portions of the Sphenoid bone, between it and the tuberosities of the Superior Maxillary bones.

Each bone is of very irregular shape, and made up of five processes: the lower and horizontal one is called the *palatine process* (a.), which passing inwards becomes thickened at its inner edge, and joining with its fellow completes with the Superior Maxillary bone above the *nasal crest* (b.) and the floor of the nose, and below the *palatine spine* (c.) and the bony Palate: from the outer edge of this process ascends the *nasal process* (d.), which completes the outer lateral boundary of the nostril, and has upon it a horizontal ridge for the Turbinated bone: the hinder part of this process is triangular, forming the *pterygoid process* (e.), consisting of a middle ridge which enters into the fissure between the inner and outer plates of the pterygoid portion of the Sphenoid, on either side of which is a groove to receive those plates. The top of the nasal process terminates in two small ones: the front one, the *orbitar* (f.), completes the floor of the orbit, and the back one, the *sphenoidal* (g.), rests against the body of the Sphenoid bone, with which the notch between the two last-named processes completes the *spheno-palatine hole*, and descending vertically from it is the *pterygo-palatine canal*, formed by the Palatine and Sphenoid bones, which terminates on the palatine process in two holes—the anterior larger one the *palato-maxillary*, and the posterior smaller the *palatine hole.*

The holes in this bone are the two just mentioned, and the Spheno-palatine by the junction of the Palatine and Sphenoid bones.

11 & 12. The Turbinated Bones (*Ossa Turbinata*, Lat.; *die Muschel-beine*, Germ.; *les Cornets Inférieurs*, Fr.) (Fig. XII.)

Are situated within the Nostrils, upon their outer walls, resting against the Superior Maxillary bones in front, and the Palate-bones behind. They are sometimes called the Inferior Turbinated bones, when the turbinated plates of the Ethmoid bone are described but wrongly, as distinct bones.

The bone consists of a pair of concave plates, with their concavities facing towards each other, and joined



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by their upper edge; the outer of these, the shorter and flatter, rests against the inside of the body of the Superior Maxillary and Palate bone, and in front reaches to the lowest point of the Lachrymal bone; the inner plate is the longer and more curved, and depends into the cavity of the nostril.

13. The Ploughshare Bone (*Vomer*, Lat.; *der Pflugschar*, Germ.; *le Vomer*, Fr.) (Fig. XIII.).

Extends from the under part of the body of the Sphenoid to the nasal crest of the Superior Maxillary and Palate bones, dividing the Nose into the two cavities or Nostrils. Its figure very much resembles a ploughshare, and its direction increases the similitude; its upper or *sphenoidal* (a.) edge is broad and short, and has in it a depression to receive the azygos process of the Sphenoid bone; its hinder or *pharyngeal* (b.) edge is knife-shaped and hollowed out; its lower or *cristal* (c.) edge is hollowed to receive within it the nasal crest, and its anterior or *septal* (d.) edge is hollowed to receive the septal cartilage of the Nose below, and the nasal plate of the Ethmoid bone above.

14. The Lower Jaw (*Os Maxillare Inferius*, Lat.; *die Unterkiefer-beine*, Germ.; *le Maxillaire Inférieur*, Fr.) (Fig. XIV.)

Is a large single bone forming the Lower Jaw, placed below all the other bones of the Head, and forming the lower boundary of the Face.

It resembles the letter U placed horizontally, with its convexity facing forwards; whilst the branches before their termination are bent upwards at right angles, and hence has originated the division of the bone into its *horizontal* (a. a.) and *ascending branches* (f. f.). The horizontal branches meeting in the front convexity form the *symphysis* or *chin* (b.), the front of which projects somewhat, and at its back are one or two little processes, called the *mental spine*; from the chin pass backwards the *sides* of the bone which terminate in the *angles* of the jaw; the lower edge of the sides and chin are rounded, and the upper is furnished with an *inner* and *outer alveolar* or *gum processes*, connected by alveolar plates, which leave between them sockets for the teeth, like those in the Superior Maxillary bones; on the inner surface of each side of the bone is a ridge for muscular attachment, and at the outer side, near the angle, a distinct roughness for the same purpose. The ascending branches rise nearly vertically, are wide from before to behind, flattened laterally, and terminate in two processes, separated from each other by a concavity; they are nearly of a height. The hinder one, the *condyloid process* (e. e.), is expanded laterally, and convex from behind to before, corresponding with the socket in the Temporal bone, and below it the bone is constructed to form its *neck* (f. f.). The front or *coronoid process* (g. g.) resembles the point of a knife, and has attached around it the tendon of the temporal muscle; this process runs sharply down to near the last alveolar cavity, and is then divided into two legs, which are lost, one on the alveolar process and the other on the side of the jaw; about half an inch below the notch, and covered by a small plate of bone, is the *inferior maxillary hole* (h. h.), which is the entrance of a canal running beneath the sockets of the teeth as far as the second bicuspid tooth, where it terminates on each side in the *mental hole* (i. i.).

The holes in this bone are the two pair just mentioned, viz., the Inferior Maxillary and the Mental.

*Junction of the Bones of the Head.*

None of the bones of the Head, except the Temporal and Lower Jaw bones are connected by true joints, *i.e.*, ligamentous capsules lined with synovial membrane, but are for the most part united by the corresponding edges of the several bones, being toothed like a saw, and the teeth received into the alternate notches, the fibrous covering of the bones being only interposed. This kind of junction, having the appearance of the bones being stitched together, has obtained the name of *Suture*, a term more generally applied to the union of the large bones of the Skull, whilst the more delicate union of those of the Face are generally called *Harmonies*, although in reality there is no difference, except in the fineness of the toothing of the bones. In some few instances two bones overlap each other, the edges of each being bevelled off, so that there is no increased thickness at their junction; such is the case with part of the union of the Temporal with the Parietal bones, and of the Turbinated with the Superior Maxillary bones.

Of the Sutures of the Bones of the Skull there are seven.

1. The *Coronal Suture*, named from being near the part upon which the victor's crown was placed in the games of the ancients. It commences about an inch behind the outer angular process of the Frontal bone, at the middle of the upper edge of the temporal plate of the Sphenoid bone, passes upwards and slightly backwards to the crown of the head, and descending forwards terminates at the opposite point to that whence it commenced, having in this course connected the hind edge of the Frontal with the frontal edges of both Parietal bones.

2. The *Sagittal Suture*, from its direction backwards straight as a dart, commences from the middle of the Coronal, passes back to the occipital angle of the Occipital bones, and connects the parietal edges of the Parietal bones.

3. The *Lambdoidal Suture* resembles the Greek letter Λ; its angle abuts on the hind part of the Sagittal, its branches pass downwards and forwards on each side, and terminate in the anterior inferior lacerated holes of the base of the Skull, connecting the parietal, temporal, and basilar edge of the Occipital bone on each side with the occipital edge of the Parietal, with the hind and under part of the Maxillary portion, and with the hind edges of the petrous portion of the Temporal bone.

4 & 5. The *Squamous Sutures*, formed by the scale-like overlapping of the squamous part of the Temporal bone and the temporal edge of the Parietal bone on each side, which describes the extent of these sutures.

6. The *Ethmoidal Suture* exists in the junction of the margin of the cribriform plate of the Ethmoid, with the notch between the orbitar plates of the Frontal bone.

7. The *Sphenoidal Suture* is the most important and most extensive of any in the Skull, and consists of the junction of this with all the bones of the Skull; by the upper edge of its temporal plates it joins the sphenoidal angles of the Parietal and that part of the Frontal which belongs to the temporal pits; by the posterior and under edge of these plates as far as the spinous processes it joins the front of the squamous portions of the Temporal bones, and thence to the body joins the fronts of the petrous portions of the same bones; the back of the

body joins the sphenoidal angle of the Occipital bone, and its front joins the back of the Ethmoid bone, extending outwards from which the transverse spinous processes join the back of the orbitar plates of the Frontal bone.

One suture, which connects the Skull to the Face, from its direction is called

The *Transverse Suture*, but a better name for it would be the *Rectangular*, the angle being situated at the junction of the pterygoid portions with the body of the Sphenoid bone. The horizontal leg connects in the middle the Vomer with the body of the Sphenoid and with the nasal plate of the Ethmoid; on each side of which the sphenoidal process of each Palate-bone joins the body of the Sphenoid, and the orbitar process of each Palate and superior Maxillary bone joins the lower edge of each orbitar plate of the Ethmoid and Lachrymal, and having reached the nasal processes of the Superior Maxillaries, ascends, connecting their hind edges with the front edges of the Lachrymal, and then running across the top of the bridge of the nose connects the top of the nasal processes of the Maxillaries and the tops of the Nasal bones with the nasal processes of the Frontal bone. The remaining part of this horizontal leg connects the hind part of the inner orbitar processes of the Malar bones with the front of the orbitar processes of the Sphenoid and the outer angular processes of the Frontal bone. The vertical leg of the Suture connects the front of the pterygoid portions of the Sphenoid with the pterygoid processes of the Palatine, and the tuberosities of the Superior Maxillary bones.

The Harmonies of the Face

Are sufficiently described by enumeration, their generally compound names indicating the bones they connect.

The *Nasal*, *Maxillary*, *Palatine*, } connecting the pairs of bones;

*Naso-Maxillary*, *Lachrymo-Maxillary*, *Palato-Maxillary*, *Malo-Maxillary*, *Turbo-Maxillary*, } connecting severally the Nasal, Lacbrymal, Palatine, Malar, and Turbinated with the Superior Maxillary bones;

*Septal*, connecting the Vomer with the Superior Maxillary and Palatine bones; and

*Zygomatic*, connecting the Malar with the Temporal bones.

### 3.—OF THE CHEST.

*Thorax*, Lat.; *der Brustkasten*, Germ.; *la Poitrine*, Fr. (Anat. Pl. III., fig. XVIII. to XXVII.)

The Chest forms the upper of the great cavities of the Trunk, and consists of thirty-nine bones,—viz., twelve pairs of Ribs connected behind with the twelve Vertebres of the Back already described, and before with the three pieces of the Breast-bone.

The Ribs (*Costæ*, Lat.; *die Rippen*, Germ.; *les Côtes*, Fr.) (Fig. XIX. to XXI.)

Are disposed in pairs below each other, and vary considerably in form. Generally they resemble segments of a circle, or of an oval, according to their position, the upper affecting a semicircular, and the middle a semi-elliptical form, whilst the lower are but small arcs of large circles. No two of the same side are of equal length; the seventh is the longest, and from it the other ribs diminish both upwards and downwards. Excepting the first pair, which are flat from above to below, all are compressed in their middle part, which is called the *body* (a.), with their upper edge round and their lower sharp and hollowed within, forming a deep groove for the lodgment of the intercostal vessels and nerves: the eleventh and twelfth pairs (fig. XXI.), however, are distinguished by having both upper and lower edges sharp. By their hinder extremities all the Ribs are connected to the Dorsal Vertebres, the upper ten doubly and the lower two singly. The double union of the former is effected by a joint-surface on the extremity of the bone called the *head* (b.), which in the first, eleventh, and twelfth Ribs is single and attached to the bodies of the first, eleventh, and twelfth Back Vertebres; but in the other nine pair the joint-surface on the head is double, each head being received not on a single Vertebre but on a shallow cup formed by the lower edge of one and the upper edge of the subjacent Vertebre, and perfected by the ligamentous structure connecting their bodies. The upper ten pairs are also further connected to the Spine, each by a little jutting process called the *tubercle* (c.), placed where the ribs bend forwards, and which has a joint-surface corresponding with that upon the transverse processes of the upper Dorsal Vertebres. The remaining two lower Ribs have no tubercles, because the Spinal pieces with which they are connected have very small transverse processes. The fore extremities (d.) of all the Ribs are more or less deeply hollowed to receive tough gristles, which have the general form of their bodies; by these the upper seven pairs are directly connected with the Breast-bone; the following three with the seventh pair of Ribs and with each other, whilst the lowest two pairs are unconnected except with the muscles of the belly; and hence the Ribs are divided into *true*, *false*, and *floating*. With regard to the position of the Ribs, neither can be said to be strictly horizontal. The first pair have the greatest pretension to that arrangement; but even in them, except under a very peculiar state of inspiration, the fore extremity is lower than the hind one, and all the other pairs depend successively more and more as they approach the lower part of the Chest.

The Breast-Bone (*Sternum*, Lat.; *der Brust-bein*, Germ.; *le Sternum*, Fr.) (Fig. XXII.)

Consists of three consecutive pieces, situated in the middle of the front of the Chest; of these the lowest piece often remains gristly or cartilaginous throughout life, and is never ossified but at a very late period. The general form of the Breast-bone is that of a short Roman sword; the handle being formed by the first, the blade by the second, and the point by the third or cartilaginous piece,—hence it is called the *Sword-like* or *Ensiform Cartilage*; but the connexion of these pieces is so firm, that although admitting of slight yielding which diminishes the shock of any blow received on the chest, yet for the purpose of sustaining the fore extremities of the ribs it is fully efficient.

The *first piece* (a.), often called the handle or *manubrium*, is of a triangular form, with all its angles truncated; its base is placed upwards at the bottom of the Neck, interposed between the two Collar-bones, which it receives upon its two angles (d. d.), semilunarly hollowed for that purpose, whilst its truncated tip is joined to

The *second piece* (b.), the blade or body, *corpus*. This

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is of a lengthened form, rather narrower at the upper than at the lower end, where it joins with the *third piece* (c.). On each side of the Breast-bone thus formed, besides the sockets for the Collar-bones, are shallow hollows in which the gristles of the seven true Ribs are received; and of these one pair and one half pair are seen on the first piece, four pairs and two half pairs on the second, and one half pair on the third piece.

*Of the Thoracic Joints* (Figs. XXIII. to XXVII.).

The two bony pieces and the sword-like Cartilage of the Sternum are connected together by thin cartilage, and this junction is strengthened by ligamentous bands which pass from above to below on both surfaces of the bone.

The heads of all the Ribs are connected to the bodies of the Vertebres by *capsular ligaments*, the sockets upon the latter being formed in all except the first eleventh and twelfth Dorsal, by the half articular surfaces on their edges connected by the Intervertebral Substance, from which a short flat band (a. c.) is extended to the horizontal ridge upon the head of each Rib, and divides the capsule into two distinct cavities lined with synovial membrane. The three excepted pairs of Ribs being received on whole sockets, as already mentioned, have not this band, and therefore the synovial capsule is single. The fronts of these capsular ligaments are materially strengthened by ligamentous bands, which, originating from the front of the Neck of each Rib, pass in three packets, one to the Vertebre above, another to that below, and a third between these to the interposed Intervertebral substance: from this spreading form they are called the *radiated* ligaments.

The tubercles of the upper ten pairs of Ribs are also connected to the corresponding transverse processes of as many Vertebres by *capsular* ligaments; and this junction is further strengthened by three ligaments, 1. The *posterior costo-transverse* (d.), a short thick one which extends from the outside of the root of the tubercle to the point of the transverse process with which it articulates; 2. The *middle costo-transverse* (e.), which connects the back of the neck of the Rib with the front of the same transverse process; 3. The *anterior costo-transverse* (f.), which, arising from the whole upper edge of the Neck, is attached to the under edge of the transverse process of the Vertebre above.

The sternal or fore extremities of the upper seven pairs of Ribs are joined directly to the Breast-bone by as many Cartilages, and the three following indirectly by successive junctions with each other, and the connexion of the upper with the seventh. The lowest two are not in any way connected with the Breast-bone, but merely tipped with Cartilage to prevent injury to the muscles among which they move. The length of the connecting Cartilages differs materially; the first pair are very short, but thence they increase to the seventh pair, which are the longest. In size and form they nearly resemble the extremities of the Ribs to which they are attached, and above the sixth the two extremities of each are rather deeper than the middle, but below it the fore end is shallower than the hind; and, indeed, those of the eighth, ninth, and tenth, which rest against each other, are pointed. Like the fore ends of the Ribs, their greatest diameter is vertical, with the exception of the first pair, which assumes the nearly horizontal position of the Ribs to which they belong; and the second pair are intermediate between the first and the others. Their direction also from the Ribs to the Breast-bone differs materially in reference to their position: the first pair follow the curve of the uppermost Ribs, and join the Breast-bone rather obliquely from above and without downwards and inwards; the second abut on the same bone at right angles; the third and following, including the seventh, ascend from below and without upwards and inwards, their junction with the Ribs being further below their sternal junction as they descend. The junction of the Cartilages with all the Ribs is direct, their costal extremities being rather semi-elliptical, and received into corresponding cavities, the margins of which overlap them; it is the kind of junction technically called a *symphysis*, or flowing together of parts. Their connexions with the Breast-bone are on the contrary true joints, *ligamentous capsules* lined with synovial membrane; but the capsules are so short that scarcely any motion is performed between them and the Sternum. The first pair of Cartilages, however, are joined to the Breast-bone directly by Symphysis, and not by a true joint. The capsule of the second pair exhibits a remarkable analogy to those connecting the middle Ribs and the Dorsal Vertebres, in being divided into two by the ligamento-cartilaginous structure which connects the upper and second portion of the Breast-bone, sending a process to the sternal end of the Cartilage. The capsules of all these Cartilages are strengthened by ligamentous fibres, which, passing inwards from them, run upon the front and back of the Sternum, and are lost in its periosteal covering. The Cartilages of the false Ribs are joined successively to the under edge of the Cartilage above them by cellular tissue, which is the shortest between the seventh and the eighth, and the longest between the ninth and the tenth; and each is connected further outwards, that is, nearer the fore end of the preceding Rib than the other. The effect of these two circumstances is, that the lower they are the more movable, and the wider the diameter of the Chest



The use of the Cartilages is two-fold; *first*, to allow more extended motion in the Ribs, which, when elevated, by twisting the Cartilages outwards and forwards, project their fore extremities, and thereby increase the size of the Chest from before to behind more than they could have done had the Ribs, Cartilages, and Breast-bone been mere osseous rings movable only at their Vertebral extremities; and *secondly*, by their elasticity, to break or diminish the shock of blows received upon the Chest, which but for them would probably cause fracture of one or more of the Cotsal Rings.

The connexion of the last two pairs of Ribs, the floating Ribs, as they are commonly called, from their fore extremities rooing among the muscles, and unattached to the Cartilages above, is merely to the bodies of the eleventh and twelfth dorsal Vertebres by capsular ligaments. They are not connected by any true joints to the small transverse processes of those Vertebres, but to the transverse processes of the upper two Loin-Vertebres by a ligament of an arched form, broad at its origin from those processes, and narrowing as it ascends outwards to be attached as far as the tips of those Ribs.

*General Observations relating to the Chest.*

*As to Form.*—The shape of the Chest nearly resembles a truncated cone, flattened before and behind, and rounded on the sides. Its truncated apex forms the lower boundary of the Neck, presenting an oval aper-

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ture, with its long diameter from side to side, and its plane facing forwards and upwards. The base faces downwards, or nearly so, and is very capacious, but its front is deficient as high as the tip of the Breast-bone, which scarcely descends below the sixth pair of Ribs; and as those below diminish in length, a large triangular gap is left.

*As to Capacity.*—The cavity of the Chest is not so capacious as might at first be supposed; for although with regard to the whole Spinal Column the Dorsal Vertebres, which form the hind part of the Chest, recede, yet their bodies project considerably into its cavity, or, in other words, the curving portions of the Ribs at their angles extend far behind these Vertebres; the effect of which is to assist the equipoise of the Trunk by placing a considerable part of the muscular coverings of the Chest behind the supporting Spinal Column. A vertical section of the Chest gives a ready explanation of this arrangement as to equipoise, whilst a transverse section, which has no very indistinct resemblance to the heart on playing cards, shows how the encroachment upon the cavity is fully compensated by the enlargement of the Chest on either side behind the Spine. It must, however, be borne in mind, that in a well-formed Chest the front, or Breast, as it is usually called, has no resemblance to the point of the card-heart, but is, on the contrary, very broad; and any diminution of this breadth, which is accompanied with corresponding projection of the Breast-bone, produces that unnatural and unhealthy form of the front of the Chest commonly known as a *Chicken-breast*, in consequence of which the cavity of the Chest is materially diminished.

*As to Motion and Variation of Capacity.*—It is not to be supposed that during respiration the Ribs either remain fixed in one position, or that when moved in *inspiration* they are raised up to one another like the pieces of a Venetian blind, and again separated in *expiration*. Were it so, there would be no increase in the size of the Chest in the former case, nor diminution in the latter, at least so far as the bony structure is concerned. But in inspiration there is an actual increase of the capacity of the Chest by the extension of its bony walls, which is effected by the simple and beautiful mechanism enabling the Ribs and Breast-bone to perform a swinging motion upon the Spine. It must be recollected that none of the Ribs are articulated horizontally with the Spine; even the first pair have their front lower than their back part, and this declination continues more and more till it acquires its greatest variation at the last pair. Any elevation, therefore, of their anterior extremity increases its distance from the Spine, and consequently increases the capacity of the Chest from behind to before, as the Ribs are raised towards a more horizontal position than they possess when at rest. The capacity, therefore, of the Chest is increased by the fore extremities of the Ribs being swung upwards; the heads of these, moving upon the Spine, form the axes of as many pairs of rods, the bodies of Ribs themselves, as are connected with the boat of the swing represented by the Breast-bone and its connecting cartilages. In Quadrupeds which have the Dorsal portion of the Spine horizontal, the comparison is very close, the Ribs depending like the rods of a common swing, whilst the Breast-bone is thrown forwards and backwards when they are put into action by the muscles of respiration. But in Man, who has the Spine erect, the swing-like motion, though still simple, is rather more complicated, because requiring a fixed point from which the swinging motion is to be initiated. This is provided in the first or uppermost pair of Ribs, which, connected by very short Cartilages to the top of the Breast-bone, and also to the first dorsal Vertebre, forms with those bones a strong ring, retained in its place above by powerful muscles antagonizing the weight of the lower Ribs and muscles attached to them, which have a constant tendency to depress it, and except under peculiar states of respiration has very little motion, and forming the fulcrum upon which all the other Ribs are moved, the elevating muscles of the second Rib rendering its front part more horizontal, and so on throughout the whole descending series, which are more and more raised as their anterior ends are more widely separated. At the time the fore part of these Ribs are being raised, in consequence of their cartilaginous connexion with the Breast-bone, they project it forwards, more especially near its tip, on account of the elevation of the Ribs being greater there than at the upper part, and consequently the capacity of the Chest is more enlarged comparatively at this point than it is above. Such is the mechanism as regards inspiration, and expiration is merely the reverse of these motions, with this only difference, that the mere weight of the lower part of the Chest restores its original position without any necessity for muscular exertion. It may, however, be briefly observed, that the Cartilages of the Ribs take part in the initiative of expiration: when the Ribs have been elevated, the cartilages undergo a kind of twist outwards; whilst this elevation is continued, their elasticity is constantly acting to recover their natural position, and by doing this they depress the ends of the Ribs connected with them.

### 4.—OF THE LIMBS.

*Extremitates*, Lat.; *die Gliedmasse*, Germ.; *les Membres*, Fr.

The Limbs of Man are divided into Lower and Upper, and their organization is subservient to certain special purposes, in consequence of which, strictly speaking, neither participates in the functions of the other. This remarkable peculiarity distinguishes them from all other animals.

By the beauty and perfection of their form, and the delicacy of the motions consequent thereon, especially those of the Upper Extremities, the Limbs of Man are far separated from those of other animals, and decidedly indicate his claim to the highest rank in the works of Creation. Two of the principal and peculiar characters which distinguish him are dependent on the arrangement of the Limbs. These are, his erect posture and the complicated functions of his Upper Extremities, with neither of which can any parallel be found in those parts of other animals. In a large portion of them the erect posture is physically impossible, as in the greater number of Beasts or Mammiferous Animals; and even in the few which affect this position, the arrangement of the Skeleton is so little suited to it, that the attempt, even for a very short time, is made only with severe exertion, and then imperfectly, as seen in the Monkey Tribe of the Four-handed or Quadrumanous Order of Beasts. The so-called erect position of Birds is not really an erect posture; for the trunk, instead of being vertical with relation to the feet, which form the base of support, is

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more or less at a right angle with them, and part even of the Lower Limbs themselves have, to a greater or less degree, a horizontal disposition. And with regard to Reptiles and Fishes, the horizontal position of the whole body always obtains. Again, the Upper Limbs in all other animals are properly called Fore Limbs, being entirely or partially employed in the support and progression of the body, and in a very large proportion serve only these purposes. In Man, however, their functions are entirely different, and the principal one is that of instruments by which a vast variety of offices can be performed by them alone, which in animals are either effected only by the consentaneous employment of several organs, or not performed at all.

### A.—Of the Lower Limbs, or Passive Locomotive Organs.

*Extremitates Inferiores*, Lat.; *die Unteren Extremitäten, oder Bauchglieder*, Germ.; *les Membres Inférieurs*, Fr. (Anat. Pl. III. and IV.)

The Lower Limbs consist of the Basin or Hip-Girdle, the Thighs, Legs, and Feet.

1. The Basin or Hip-Girdle (*das Becken*, Germ.; *le Bassin*, Fr.) (Pl. III., figs. XXVIII. to XXXV.)

The Hip-Girdle, Basin, or Pelvis, as it is generally called, forms at once the lower great cavity of the Trunk, and the medium of connexion between the Trunk and the Lower Limbs, specially so called. It consists of four bones—the Rump and Tail Bones, already described (p. 383), and the two pelvic bones.

The Pelvic, or Hip Bones (*Ossa Coxarum, seu Innominata*, Lat.; *die Huft-beine, oder Seitenbeinknochen*, Germ.; *les Os Iliaques*, Fr.) (Fig. XXVIII. to XXXII.)

Are a pair of bones which occupy the fore and side parts of the lower portion of the Trunk, and are of very irregular form.

The largest part of the Bone is expanded in a fan-like shape, and its margin forms the Hip, commonly so called. Its comparative size is greater than in any other animal, because required to give attachment to the large muscles which preserve the vertical position of the Trunk upon the tops of the Thigh-bones. It has upon its inner and back part a large joint-surface, which closely connects it with the Rump-bone, whilst before and below it becomes thick and bulky, to admit the sinking of the *concavity* of part of the socket (r.) of the Hip-joint. It has also four little jutting processes called *spinous*—two in front, the *superior* (a. a.) and *inferior anterior* (b. b.), and two behind, the *superior* (c. c.) and *inferior posterior* (d. d.); and between the upper of these is the thick upper margin of the bone, called its *crest* (e.). The outer surface of the bone is called its *back* (f.) and the inner its *belly* (g.), bounding the lower part of the latter of which is a blunt ridge called the *ilio-pectineal line* (h.). This portion of the Pelvic bone is anatomically named the Hip-bone (*Os Ilii*, Lat.; *das Darm-bein, oder Huft-bein*, Germ.; *l'Os de Iles*, Fr.), and it is joined to the Hip-socket by an irregularly oval ring forming the front of the bone, and described as consisting of two pieces, the Haunch-bone and the Share-bone. It must, however, be observed, that in the adult state the Pelvic bone is really not composed of three pieces, although such is the case in the young subject, from which circumstance anatomists have been pleased to describe it as three separate bones, an erroneous proceeding, which has been followed by almost every writer on the subject. The upper and inner part of the already mentioned bony oval is called the Haunch-bone (*Os Pubis*, Lat.; *das Sham-bein*, Germ.; *le Pubis*, Fr.); the most remarkable points of which are its thick concave part, where joining with the Hip-bone, to form the inner upper part of the Hip-socket (r.), thence extending inwards horizontally, its *body* (i.) terminating at its *angle* in the descent of the *leg* (i.) of the bone, the inner and upper part of which is broad and irregularly rough to join its fellow, and form the *symphysis* (k.). The upper edge of the body is sharp and narrow, completing in front the *ilio-pectineal line*; whilst the fore and upper surface of the same part is flat, for the passage of the blood-vessels from the belly into the thigh. The leg of the Haunch-bone, as it descends, inclines outwards, and soon assumes the name of *leg* (l.) of the Share or Sitting bone (*Os Ischii*, Lat.; *das Sitz-bein*, Germ.; *l'Ilion*, Fr.), which forms at the lower part of the Pelvic bone a large swelling process called the *tuberosity* (m.), on which the body rests in the sitting posture, and rising again upwards and outwards, expands to form the upper part of the Hip-socket, from behind which projects its *spinous process* (n.), dividing the hinder and lower margin of the bone into two notches, called the *lesser* (o.) and *greater ischiatic*. (p.). Between the lower edge of the Hip-socket and the tuberosity, there is a horizontal groove for the passage of a muscle.



Two parts, formed in the Pelvic bone, require notice.

1st. The Oval hole (q.), *foramen ovale, seu thyroideum*. This is produced by the pubic and ischiatic portions, and its oval area, as will be hereafter noticed, is filled up with ligament, for which purpose its inner margin is thin. The object of this hole is to lighten the bone as much as possible, without diminishing its strength.

2nd. The Hip-socket (r.) (*Acetabulum*, Lat.; *die Pfanne*, Germ.) is made up by the union of all three portions of the Pelvic bone, but not in equal parts, as the fore and inner fifth only belong to the Haunch-bone, whilst the rest is nearly divided equally by the Hip-bone above and behind, and the Share-bone below and before; the latter, however, has the larger proportion. The form of this socket resembles a deep cup, and from its fancied likeness to an antique vinegar cruet has received the name of *Acetabulum*. The plane of its diameter faces forwards, a little outwards and rather downwards, in consequence of which the upper edge of its lip overhangs the lower, and provides a large surface to rest on the head of the Thigh-bone. The margin of this cavity is deficient at the inner and under part, which, however, in the recent state is perfected by a strong ligament. By this formation greater extent of motion is allowed to the thigh than could be otherwise enjoyed. The greater part of the cavity is smooth; but, from the notch, a broad shallow depression is scooped out as far as the middle.

The Pelvic bones, connected together in front, are separated from each other behind by the Rump-bone, and these, together with the Tail-bone, form the Basin or Pelvis; but before treating of this cavity, it will be necessary to describe the junctions of these bones, or—

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*The Pelvic Joints* (Fig. XXXIII. to XXXVI.).

The Rump and Tail bones are common to the Spine and Pelvis. With the former they complete the pillar supporting the Trunk, and the canal in which the Spinal Cord is lodged; whilst at the same time they, the Rump-bone especially, form the hind part of the latter, the crown of the arch by which the Trunk is supported upon the Lower Limbs. Such being the use of the Pelvis, it is to be expected that the junction of the bones composing it should be of the firmest kind, as is actually the case; the only motion permitted between them being a slight yielding to diminish the shocks to which the Pelvis must naturally be exposed by its position between the Trunk above and the Lower Limbs below.

The Pelvic bones are connected by the broad irregular joint-surfaces at their inner and hind part with the corresponding surfaces on the sides of the Rump-bone, a very thin layer of fibro-cartilage, in some parts so soft as almost to resemble the mucous-like centre of the Intervertebral Substance, being interposed. Over the front and back of this so-formed junction, bands of ligament, flat and expanded, extend from the surface of one bone to the other, and are lost in their periosteal covering; these, from their position, are called the *Anterior* (c.) and *Posterior Sacro-iliac Ligaments* (b.).

The Pelvic bones are also joined to the Spine by two short stout ligaments originating from the superior posterior spine of the Hip-bone, and called the *Inferior* and *Superior Ilio-lumbar;* the former attached to the transverse process of the last Lumbar, and the latter to the same processes of the two lower Lumbar Vertebres. The connexion of the Hip-bones with the Sacral and Coccygeal parts of the Spine is further strengthened by two pairs of very strong ligaments of a triangular shape, called *Sacro-ischiadic*, the *anterior* (e.) of which has its base connected with the side of the last segment of the Rump-bone and of the three upper pieces of the Tail-bone; it passes outwards, collects together, and forms a thick flatttened mass which is fixed into and around the spine of the Share-bone, on which account it is often called *Sacro-spinous*. The other, or *posterior* (f.), is much larger and stronger; its base is attached to the lower posterior spine of the Hip-bone, to the side of the transverse processes of the three lower segments of the Rump-bone, and to the first of the Tail-bone; it curves behind the anterior, collects together into a broad flat band as it passes down to be spread upon the tuberosity of the Share-bone, where it is confounded with a large mass of fibro-cartilage by which that process is covered; from its connexion it is also called the *Sacro-tuberose Ligament*. By the extension of these ligaments between the Rump and Tail bones above and the spine and tubercle of the Share-bone below, the notches existing in the latter are formed into complete holes, the *Superior* (p.) and *Inferior Sacro-ischiadic* (o.), for the passage of muscles, vessels, and nerves.

The junction of the Share-bones in front, completing the ring of the Basin, is by concentric elliptical layers of ligamento-cartilaginous substance (i.) like that between the Vertebres, closer and tougher at the circumference, but almost mucoid in the centre; the fibres of this structure are horizontal, and the long axis of their oval vertical corresponding with the joint-surfaces of the bones connected. From one Haunch-bone to the other, ligamentous fibres (g.) cross and decussate in every direction on the surface of this structure, which they materially strengthen; and so firm is the connexion of this mass to the bones, and so great its strength, that they are rarely separated from the bones, or torn in two, the bones themselves commonly being fractured in preference.



The Oval holes in front of the Pelvis are filled up with ligamentous expansions, which are called the *Thyroid* or *Obturator Ligaments* (h.), and have at their upper and outer part an aperture through which pass vessels and nerves.

By the junction of the Pelvic-bones with the terminal pieces of the Spine is formed

The Basin (*Pelvis*, Lat.; *das Becken*, Germ.; *le Bassin*, Fr.),

The second bony cavity of the trunk. It is a hollow cylinder, the upper part of which is much outspread on the sides by the bellies of the Hip-bones, but is deficient in front as low as the pubic symphysis, from which, extending round on either side to the Rump-bone, are the *Ilio-pectineal lines;* these, taken together with the projecting front lip or *promontory* of that bone, form a ridge somewhat resembling the outline of a card-heart, which is called the *Brim* or entrance of the Basin, and divides it into parts, the False and True Basin.

The *False Basin* (fig. XXVIII. g. g. i. l.), situated above the Brim, has no bony walls in front, but its sides are formed by the expansions of the Hip-bones, and its back by the lower Lumbar Vertebres.

The *True Basin* (h. h.) is below the Brim, which forms its upper opening, and has a somewhat circular or oval form, according to the sex; the former being the characteristic of the male and the latter of the female. The front and sides are formed by the Haunch and Share bones, and the back by the Rump and Tail bones. They do not, however, form a complete bony boundary, but only, as it were, three bony angles depending about an inch below the margin of the Brim, and terminating in the tuberosities of the Share and the tip of the Tail bone. The divergence of the tuberosities leaves an angular space in front, commonly called the *Arch of the Pubes;* and between them and the Rump and Tail bones behind are a pair of holes, the Inferior and Superior Ischiadic, bounded below by the attachment of the ligaments of the same name. The hinder or lower opening of the True Basin is called the *Outlet* (fig. XXXI.); it is of a quadrangular shape, the angles being formed on the sides by the Ischiatic tuberosities, behind by the tip of the Tail-bone, and before by the Pubic joint.

The plane of the Brim of the Pelvis is not horizontal, for if it were the weight of the Trunk received on the Rump-bone would throw the body backwards; but it faces forwards and upwards, and the Outlet is nearly parallel to it. This arises from the superior anterior spinous processes of the Hip-bones touching the same vertical plane as the top of the Pubic joint, which make the Ischiatic tuberosities the lowest points of the Pelvis, and indeed the only parts upon which the body rests in the sitting posture, and through them passes the imaginary plane which drops from the basilar process of the Occipital bone through the



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Ankle-joints. The Axis of the Pelvis is a line which passes through the centres of the Brim and Outlet, and if continued upwards and forwards would pierce the Navel. These are points of great importance not merely with reference to the mechanical offices of the Basin, but also in relation to many practical points in Surgery and Obstetrics.

*General Observations relating to the Basin.*

First, *As being the means by which the weight of the Trunk is transmitted to the Lower Limbs.*—With reference to this circumstance, a horizontal line must be supposed to pass from one side to the other below the Hip-sockets; these will then form two pieces, from which springs up an arch consisting of the upper part of the brim, the keystone of which is the Rump-bone, received between the Iliac portions of the Pelvic bones. The bases of the piers are connected firmly together by the front of the Basin, so that, being unable to start aside, they afford an upward pressure, and, resisting any weight with which the arch is loaded, materially strengthen and assist in keeping the whole bony ring of the Basin together. The weight of the Head, Trunk, and Upper Limbs being deposited on the Rump-bone by means of the Spine, is transferred to the bases of the piers, namely, the Hip-sockets, which rest upon the heads of the Thigh-bones, and with the object of more perfectly steadying this junction, and to guard against any falling outwards, the outer margins of the Hip-sockets are much developed and overlap the heads of the Thigh-bones.

Secondly, *As being the fulcrum on which the motions of the Lower Limbs are performed, or vice versâ.*—The slightest consideration of the bulk and strength of the muscles by which the Lower Limbs are moved naturally leads to the presumption that the part upon which they move should be made as strong and as firm as possible, to render their motions effective. It is on this account that the Pelvic bones, which are as truly part of the Lower as the Clavicles and Blade-bones are of the Upper Limbs, instead of being movable like them, or, when immovable, principally fixed by muscles, are firmly connected to each other and to the Spine. But the purpose intended by the immobility of the Basin is not merely to afford a point of resistance whence the muscles moving the Thigh and Leg may act, but also to avoid the necessity of a large mass of muscles which would be requisite to render it sufficiently steady were the Basin movable upon the Trunk like the Shoulder-bones, before the muscles operating on the Thigh and Leg could act. As it is, however, the Basin can be firmly fixed upon the head of one Thigh-bone by those muscles which support the erect posture; whilst the same muscles, acting upon the other Thigh, the foot being first disengaged from the ground, throw the limb forward, and at the same time pointing the toe, lengthen the Leg, so that the foot again touches the ground; and in its turn becoming the point of resistance, the muscles passing between the Lower Limb and the Pelvis act upon, bring it forward and transfer the weight of the Trunk to that Limb which had been but now advanced, leaving the other which had previously supported the body at liberty to be moved forwards. In this manner, at every step, does the Basin become alternately the part from which motion commences and that which is moved; the only change in its position consisting in a little inclination to that side which is to be fixed, whilst the other Limb is slightly raised from the ground prior to its advancement.

Thirdly. *As to the movements of the Spine upon it.*—These are very slight, and confined merely to a little flexion and extension. The Pelvis may also reciprocate this motion upon the Spine, but for this purpose it is necessary that the Trunk should be horizontal.

Fourthly. *Its motions upon itself* are extremely confined, the close junction of the pubic portions with each other, and of the Iliac portions of the Pelvic bones with the Rump-bone, precluding other than a slight yielding, which saves the jarring of the bony ring in all the varieties of motion which are performed upon it. The lower part of the Tail-bone, however, forms an exception, at least in early life, to this unyielding connexion; its last segments are capable of being thrust backwards, and so increasing the size of the outlet under particular circumstances, which is especially seen in parturition.

Fifthly. *As forming a large cavity for the lodgment of important parts.*—In the True Basin are protected part of the Alimentary Canal, and also of the Urinary and Reproductive Organs. The expansions of the Hip-bones in the False Pelvis also give lodgment to important parts of the Large Intestines.

2. The Thigh-bone (*Os Femoris*, Lat.; *die Oberschenkel-bein*, Germ.; *l'Os de la Cuisse*, Fr.) (Pl. IV., fig. 1.).

This, which is the largest bone in the body, has a cylindrical form, but slightly curved forwards; its forepart (a.) is very smooth, but behind it is pinched up, as it were, to form a prominent ridge or rough line, *linea aspera* (b.), which serves at the same time to support the bowing forward of the shaft of the bone, and to increase the surface for muscular attachment without materially increasing its bulk. At each extremity the bone is much larger than in the middle; at its upper end a strong process rises above its outer edge, which is called the *great trochanter* (c.); and about two inches below this and to the inner side, is a strong rounded process called the *little trochanter* (d.), remarkably developed from giving attachment to the large muscles which bring the Thigh forwards on the Trunk in progression. Extending inwards and upwards from between these two processes, and forming an arc of a large circle, is the *neck* (e.) of the bone, which terminates in a large rounded smooth surface, with its convexity facing upwards and inwards, and having a small irregular pit in it: this is called the *head* (f.), and, being received into the Hip-socket with it, forms the Hip-joint. The lower end of the bone is largely expanded, forming two large processes, the *condyles* (g. h.), of which the *inner* (g.) is the larger and longer; they are separated below and behind by a deep *pit* (i.), are convex from above downwards, and slightly from side to side, so that they are inclined towards each other. Four *joint-surfaces* are found upon them; the *upper* and *anterior* two (j.), of which the outer is the larger for the knee-cap; the *under* and *posterior* (k.), of which the inner is the larger, for the top of the Shin-bone; the latter two occupy by far the greater portion of the lower end of the Thigh-bone, affording surfaces on which the Shin-bone describes full two-fifths of the circumference of a circle.

The position of the Thigh-bone between the Basin

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 and the Leg is not vertical, but inclining from above downwards and inwards, so as to bring the knees closer together, and consequently near the imaginary line which, passing through the centre of the body, falls between the feet.

Of the Hip-Joint (Anat. Pl. III., fig. XXXVI.; Pl. IV., figs. II. and III.).

The deep cup-like cavity of the Acetabulum or Hip-socket, and the head of the Thigh-bone, are connected together by two ligaments, and the former is considerably deepened by an edging of fibro-cartilage, which forms a ring continued from one point to the other of the gap at its inner under part, and this portion is sometimes called the *Transverse Ligament* (Pl. III., fig. XXXVI. j.). From around the circumference of the Acetabulum, the longitudinal fibres of the *Capsular Ligament* (Pl. IV., fig. II. a.) pass to the Thigh-bone, and, running over its head, are attached in front to a line running between the two trochanters, but behind they reach only to about the middle of the neck of that bone. This ligament is very thick at the fore upper and outer part where the head of the Thigh-bone is least guarded. The *Round Ligament* (fig. III. b.), as it is improperly called, being nearly flat, originates by a broad expansion from the pit in the bottom of the Hip-socket, and mounting upwards and outwards is firmly connected with the pit in the head of the Thigh-bone. The use of this ligament is to prevent dislocation of the Thigh-bones when the legs are far separated from each other outwards. The joint is a true one, the joint-surfaces being covered with cartilage upon which the synovial membrane is stretched, and thence expanded upon the Round Ligament, and over the interior of the Capsular.

The junction of these bones forms a ball-and-socket-joint, in which the largest extent of motion is permitted; flexion, extension, adduction, abduction, and the succession of these, circumduction, can all be and are constantly performed at the Hip-joint.

In order to prevent frequent repetition, the consideration of the mechanism of this joint, in reference to the support it affords the Trunk, and the motions which in locomotion the Thigh-bone performs upon the Hip-socket, and the reverse, must be deferred till the whole Lower Limbs and their Joints have been described.

3. The Leg (*Crus*, Lat.; *die Unterschenkel*, Germ.; *la Jambe*, Fr.) (Anat. Pl. IV., fig. IV. to VI.)

Consists of three bones, the Shin-bone, Knee-cap, and Splint-bone. Strictly speaking, however, there are only two, as the knee-cap is merely a movable process of the Shin-bone, the analogy to which is found at the elbow-joint in the olecranon process of the Ulna or Cubit, which has the same office and similar position, whilst it forms an integral part of the bone itself.

a. The Shin-bone (*Tibia*, Lat.; *die Schien-bein*, Germ.; *le Tibia*, Fr.) (Figs. IV. and IV.*)

Receives its technical name from its supposed resemblance to the form of an antique flute. It is a large long bone, of prismatic shape, with its base behind and its apex in front; the latter is in common language called the *Shin* (a.), and is visible through the skin, by which alone it as well as the inner surface of the prism is covered, whilst the other two faces are enveloped in muscle. The upper end of the bone, called its head (b. c. d.), is much expanded, specially from side to side, of an oval form, and having two joint-surfaces (c. d.) upon it, each of an oval form, and the inner (c.) the larger, and separated from each other by a short stumpy process (e.), bounded before and behind by a pit; these surfaces are slightly concave, have their long axes from before to behind, and receive upon them the joint-surfaces of the Thigh-bone. On the outer under part of the head is a flattened joint-surface (f.) for the Splint-bone; and below the front of the head is a projection called the tubercle (g.), to which the knee-cap is connected by ligament. The lower end or base (h.) has a joint surface (j.) concave from before to behind for the Astragal; on its outer side is an irregular one for the lower end of the Splint-bone, whilst its inner edge depends considerably, and forms a large process called the inner ankle, *malleolus internus* (k.), which has a joint-surface on its outside for the Astragal, and thus protects in that part the Ankle-joint; behind it is a groove for the passage of one of the flexing tendons into the sole of the foot.

b. The Knee-cap (*Patella*, Lat.; *die Kniescheibe*, Germ.; *la Rotule*, Fr.) (Figs. V. and V.*)

Is really, as before stated, a mere movable process of the Shin-bone, which in some of the Water-Birds is fixed. It is of a triangular shape, with the base uppermost; it has two joint-surfaces (a. b.) behind, of which the inner (a.) is the larger, received on the upper joint-surfaces of the condyles of the Thigh; the bone in front (c.) is rough. Its primary use is to lengthen the lever which by the extending muscles act upon the leg, and so render their action more powerful. Secondarily, it protects the front of the knee-joint from injury, which it does very effectually in whatever position the leg may be placed, in consequence of its ligamentous connexion with the Shin-bone allowing its perfect adaptation to the joint-surfaces of the Thigh-bone.

c. The Splint-Bone (*Fibula*, Lat.; *die Waden-bein*, Germ.; *le Péroné*, Fr.) (Figs. VI. and VI.*).

The Splint-bone is a long thin bone placed on the outer side of the Shin-bone, and marked by several longitudinal sharp ridges and grooves to increase its surface for the attachment of muscles. At the upper and inner part it is connected to the Shin-bone by an oblique flat joint-surface, and from the outside of this springs up a little process called the *bicipital* (a.), which gives attachment to one of the flexing muscles of the leg. At the lower end it is also connected with the outside of the Shin-bone, but its extremity descends below that junction to protect the outer side of the ankle-joint, forming a large process called the outer ankle (b.), *malleolus externus*, which has on its inner side a large triangular joint-surface for the Astragal; and behind it is a groove for the passage into the foot of two of its extending muscles.

The use of this bone, which, excepting at its extremities, is at some distance from the Shin-bone, is first, to make a broad surface for the attachment of muscles, at the same time that it strengthens the Shin-bone by its splint-like connexion with it; secondly, it protects completely the outside of the Ankle-joint.

Of the Knee-joint (Anat. Pl. IV., figs. VII. VII.* VIII.).

The Articular surfaces in this joint are eight; a pair on the front of the Condyles of the Thigh-bone to cor-



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Anatomy. respond with a pair on the Knee-cap, and a pair on the under and back part of the same processes, which answer to a pair on the head of the Shin-bone; their form and extent have been described above.

The Knee-cap, as already mentioned, being merely a movable process of the Shin-bone, its flexible connexion, the *Ligament of the Patella* (a.), is so strong that it even exceeds the tenacity of bone, as proved by the frequent occurrence of transverse fracture of the Knee-cap by muscular action, whilst the ligament remains uninjured. It is very wide and thick, attached to the tubercle of the Shin-bone below, and rising up vertically begins to be fixed on the apex of the Knee-cap, and thence along its sides and front surface, and becomes confounded with the periosteum.

To the edges of the Knee-cap is also attached the *Capsular Ligament* (b. b.), the fibres of which pass from above the articular surfaces of the Thigh-bone to below those of the Shin-bone, including them in a capsule, into the front of which the Knee-cap is, as it were, let in, strengthening it before, whilst on the sides and back the capsule is strengthened by other ligamentous bands. One, extending from the fore and inner part of the inner condyle, and spreading out in a triangular form as it is attached below the inner side of the head of the Shin-bone, is called the *Internal Lateral Ligament* (c.); another, like a thick cord passing from the outer and back part of the outer condyle, descends to the outside of the head of the Splint-bone, where it it is attached, and is called the *Long External Lateral Ligament* (d.), as a second shorter, broader, but less strong one passes behind it between the same bones, and is called the *Short External Lateral Ligament*. The direction of all these lateral ligaments is rather backwards as well as downwards, so that when the Knee is bent they are slack, but when straight are tense. From the upper and back of the outer condyle originates the *Posterior Ligament* (e.), which, spreading as it passes over the back of the Capsule, is fixed to the back and inner part of the head of the Shin-bone.

All the just described fibrous bands are external to the Capsular ligament, and with the purpose of strengthening it, which they do materially; but both they and it are merely secondary agents in the connexion of the Thigh with the Shin-bone. This is principally effected by a pair of strong cord-like ligaments within the capsule, which, in consequence of their crossing each other, are called *Crucial* (f. g.). The *Anterior* or *External* (f.) is the shorter of the two; it arises from the back and inner surface of the outer condyle, passes forwards and inwards to be fixed in the pit between the front of the articulating surfaces on the top of the Shin-bone; the *Posterior* or *Internal* (g.), commencing from the outside of the inner Condyle by a very wide semilunar root, passes downwards and backwards, and is fixed in the pit between the hinder margins of the articular surfaces on the head of the Shin-bone, and also connected with the little process which separates this from the anterior pit.

The articular surfaces on the head of the Shin-bone which receive the Condyles of the Thigh-bone, are, so far as the bone is concerned, very shallow; but to prevent the Condyles from sliding off when the Knee-joint is bent, at which time all the ligaments except that of the Knee-pan are lax, they are deepened by a pair of *Interarticular Cartilages*, which from their form are called *Semilunar* (h.), and are attached around the head of the Shin-bone, their extremities nearly meeting at the insertion of the Crucial ligaments; their external circumference is about the eighth of an inch deep, but as they extend inwards towards the centre of the joint they gradually diminish in thickness, so that their interior edge is quite sharp; their breadth varies from three-eighths to half an inch, and the outer is the deeper, and its circumference nearly completes a circle; by their outer margins they are connected with the capsular ligament which connects them with the head of the Shin-bone, and they are attached to one another before and behind by *Transverse Ligaments*. Anatomy

The Knee is a hinge-joint, flexion and extension only being the motions for which it has been specially formed; but when bent all the ligaments are, to a certain extent, relaxed, and a slight rotation between the Thigh-bone and Shin-bone is permitted, which is greatest outwards. On the contrary, when the Knee is straight all the ligaments except the Capsular are quite tense, so that the leg is compelled to follow entirely whatever motions are performed at the Hip-joint.

### *Junction of the Shin and Splint-bones.*

For the purpose of diminishing the weight of the Leg without lessening the surface for muscular attachment, it is composed of two bones connected at their upper and lower ends, and having between them an aponeurosis or fibrous expansion called the *Interosseal Ligament*; improperly, as Cruveilhier has justly remarked, for its use is not to connect the bones, but to provide a surface for the origin of muscles; their only true connexion being above and below. The *upper* junction is a true joint, admitting of no motion beyond a slight sliding, the surfaces being flat and contained within a strong straight Capsular Ligament. The *lower*, on the contrary, is not a true joint; neither bone has an articular surface, and they are immediately connected by a mass of fibro-elastic ligament, which forms but a thin bed between them. This is strengthened by two short bands passing from the fore and back part of the outer edge of the base of the thin bone to corresponding parts on the malleolar process of the Splint-bone, which are called *Anterior* and *Posterior Fibro-Peroneal Ligaments*, of which the latter is the strongest, and descends lower.

4. The Foot (*Pes*, Lat.; *der Fuss*, Germ.; *le Pied*, Fr.) (Anat. Pl. IV., fig. IX. to XVIII.)

Consists of three portions,—the Tarsus, Metatarsus, and Toes: the former two of these compose an arch upon which the whole weight of the body rests; whilst the latter, by clinging to the ground, tend to steady it when the body is at rest in the upright posture, and, when progression is performed, assist in giving the muscles a fixed point of resistance, by which the leg is bent forwards upon the foot, and the first effort at bringing the body forward made.

a. The Tarsus (*Tarsus*, Lat.; *die Fusswurzel*, Germ.; *le Tarse*, Fr.) (Fig. IX. to XVI.).

The Tarsus consists of seven bones of very different form, but, when connected together, making up the hinder half of the Arch of the Foot.

1. The uppermost bone is called the Astragal (*Astragalus*, Lat.; *das Sprung, oder Knöckel-bein*, Germ.;

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 *l'Astragale*, Fr.) (figs. IX. a. and X.); in common language it is named the Knuckle-bone; and it is that by which the Foot is connected with the Leg. It has a *convex joint-surface* above (a.) to receive the lower end of the Shin-bone, and on either side a *hollow surface* against which rest the ankles, that for the outer (b.) being the longest. It may be remembered that the ankles extend below the base of the Shin-bone, consequently the Astragal is received between them, and thus a most perfect hinge-joint is produced, so that it is almost impossible to have displacement of this bone from the ankle-joint without fracture of one or both of the ankles. Upon the under surface are two *joint-surfaces* for the Heel-bone, which affect a lengthened shape, and on the fore part is a *rounded joint-surface* (c.) for the Navicular bone.

2. The Heel-bone (*Os Calcis, seu Calcaneum*, Lat.; *das Fersen-bein*, Germ.; *le Calcaneum*, Fr.) (Fig. IX. b. XI.) is the largest of all the Tarsal bones, and of an irregularly rhomboidal figure. It is nearly flat on the outer side, but on the inner side has a deep hollow called the *sinuosity*, formed by the overhanging of the *inner* (b.) of the two *joint-surfaces* (a. b.) on its upper surface for the Astragal. Through this hollow the flexing tendons, the muscles, vessels, and nerves, pass into the sole of the foot, and are protected from pressure. On the front of the bone is an irregularly *plain surface* (c.) for its junction with the Cuboid bone; but the most remarkable point in it is the *tuberosity* (d.), a large protuberance extending considerably behind the Ankle-joint, and in common language called the *heel*. This, whilst increasing the expanse of the sole, and thereby rendering the base of support for the body more steady, also affords a powerful lever, by means of which the extending muscles are able to raise the hind part of the foot; and if it be fixed by the toes grasping the ground, it elevates the body upon the foot. It is also well worthy of notice, that man is the only animal in which the heel touches the ground, and it therefore forms one of his generic characters.

The four following bones compose that part of the Arch of the Foot commonly known as the *Instep*:—

3. The Navicular bone (*Os Naviculare, seu Scaphoideum*, Lat.; *das Kahn-bein*, Germ.; *le Scafoide*, Fr.) (Fig. IX., c. XII.), so called from its resemblance to a coracle or skin boat, is placed in front of the Astragal. Its hinder end (b.) has a large *cup-like joint-surface*, into which it receives the rounded head of that bone, in consequence of which greater motion is performed between these two than any other bones of the foot. Its front (a.) is slightly convex, and received into a similar, but more shallow cup, formed by the Cuneiform bones; and upon its inner under surface is a *stout knob*, to which a large tendon is attached.

4, 5, 6. The Cuneiform bones (*Ossa Cuneiformia, seu Sphenoidea Tarsi*, Lat.; *die Keil-beine*, Germ.; *les Os Cuneiformes*, Fr.) (Figs. g. d. e. f., XIII., XIV., and XV.) are wedge-shaped, the inner having its *base* below, and the outer two above. The inner (fig. XIII.) is the largest; the middle (fig. XIV.), the shortest and smallest; and the outer (fig. XV.), of intermediate size. As they are all placed side by side, they have *joint-surfaces* connecting them with each other; but the outer has a large *joint-surface* on its outside for the Cuboid bone, and the inner a *knob* on its inside for the attachment of a tendon. Their hinder ends have *joint-surfaces*, which together form a shallow cup for the Navicular; but in front, consequent upon the shortness of the middle bone, a mortise is left which receives the hinder extremity of the second Metatarsal bone, which is further connected by corresponding joint-surfaces on the inner and outer Cuneiform-bones. 

7. The Cuboid bone (*Os Cuboideum*, Lat.; *das Würfel-bein*, Germ.; *le Cuboide*, Fr.) (Figs. IX. g. XVI.) resembles a flattened cube, is placed in the same rank as the Cuneiform bones, but on their outer side. Its hinder *joint-surface* connects it with the Heel-bone, but before it does not extend so far forward as the outer Cuneiform bone, which in its turn forms the tenon mortising with the Metatarsal bones. Its under surface is *grooved* deeply for the passage of an important tendon, which assists materially in supporting the transverse arch of the foot.

b. The Metatarsus (*Metatarsus*, Lat.; *der Mittelfuss*, Germ.; *le Metatarse*, Fr.) (Fig. IX. b. h. XVII.) is placed between the last row of the Tarsal bones and the roots of the Toes, which it supports. It consists of five bones of an irregularly cylindrical form, with a slight compression. Their hinder ends or *bases* (d.) have flattened joint-surfaces which connect them with the Cuneiform and Cuboid bones, whilst their front extremities or *heads* (e.) are rounded to receive upon them the first row of the Toe-bones. Three of them are distinguished from the others: the *first* (a.), which supports the Great Toe, by its shortness and thickness; the *second* (b.), by its great length and slenderness; and the *fifth* (c.), which joins the Little Toe, by a protuberance which projects beyond the outer edge of its tarsal joint-surface. They are firmly connected with the Tarsal bones by dove-tail or double mortise and tenon. The lengthening of the second bone forms the tenon received into the mortise of the Cuneiform bones; whilst the third, or middle bone, being shorter than either of the others beside it, leaves a second though shallow mortise in the opposite direction to that just mentioned, into which the front end of the outer Cuneiform bone is locked.

c. The Toes (*Phalanges digitorum Pedis*, Lat.; *die Zehenglieder*, Germ.; *les Orteils*, Fr.) (Fig. IX. i. i. XVIII.) consist of fourteen bones, disposed in three rows (b. c.), *phalanges*, excepting that of the Great Toe (a.), which anatomically is called the Foot Thumb, *pollex pedis*, as it really is in some Beasts, and in the whole Class of Birds, and has but two rows. The bones belonging to it are, however, of greater size than the others; indeed, equals them altogether. This remarkable bulk, at the expense of the others, indicates the greater importance of this member of the foot, upon which, indeed, at every step, the whole weight of the body is received. The general form of the first two rows is similar, except in their hinder ends or *bases*; those of the first row being cup-like, to receive the rounded heads of the Metatarsal bones; whilst the bases of the second and third rows are composed each of a slight concavity, with a middle ridge corresponding to the *heads* of the row immediately behind them, which are of a semicircular form, with a middle depression. The front ends of the third row are distinguished from those of the other two in not having any joint-surfaces, but becoming thin and expanded to support the nails.

### *Of the Ankle-Joint* (Fig. XIX. XIX.*).

The bones composing this joint are the Shin and Splint bones above and on the sides, and the Astragal

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below. Like the knee, it is a true and a hinge joint; but, in order to prevent the possibility of lateral displacement, the base of the Shin-bone sends down the process called the Inner Ankle, and the Splint-bone that called the Outer Ankle, which completely lock in the Astragal on the sides.

The six articular surfaces of these bones are included in one common loose *Capsular Ligament* attached around their margins. This is strengthened by ligamentous cords passing from the Outer Ankle to the Tarsal bones by one broad band from the Inner Ankle to the Tarsus also.

Of the three *Peroneo-tarsal Ligaments* the *anterior* (a.) is the shortest; it passes from the front of the malleolar or ankle process to the fore and outer part of the Astragal; the *posterior*, which is the strongest, passes from the back of the same process obliquely inwards to the inner back part of the latter bone; and the *exterior* (h.), called also *perpendicular*, descending vertically from the point of the Outer Ankle, is fixed in the outside of the Heel-bone.

The inner, or *Tibio-Tarsal Ligament*, named also from its form *Deltoid* (c.), originates broadly from the lower edge of the Inner Ankle, spreads out as it descends, and is attached at first to the Astragal below by its base to the upper edge of the sinuosity of the Heel-bone, and by its front angle with the inside of the Navicular bone. It thus not only connects the Leg to the Foot, but strengthens the two hinder Tarsal joints at their inner edge where they are weakest.

Flexion and extension are the special motions of this joint, but when the foot is extended upon the leg there is a slight degree of lateral motion.

### *Junction of the Tarsal Bones.*

The Tarsal bones are connected to each other by *Capsular Ligaments*, strengthened by short flat ligamentous bands, which spread out in different directions; they are named from their situation upon the upper surface of the Foot, *Dorsal*, and upon the under *Plantar*: of these the latter are strongest on account of having to maintain the Tarsal Arch, and two of them require especial notice. The *Great Inner Plantar* or *Calcaneo-navicular Ligament* (fig. XIX.* d.) extends from the whole under surface of the anterior Astragalar articular surface of the Heel-bone to the under surface and tubercle of the Navicular, and completes the bottom of the large cup into which the rounded head of the Astragal is received; and to which a considerable portion of the weight of the body is transmitted. The *Great Outer Plantar* or *Calcaneo-cuboidal Ligament* passes from the fore and under part of the Heel-bone, to which it is broadly attached, forwards to the under part of the Cuboid bone, upon the whole of which it is spread out as far as the hinder edge of its transverse groove. This is the strongest of all the Plantar Ligaments, and materially supports the outer arch of the Tarsus.

All these Joints, with one exception, are formed by flat surfaces which allow merely a sliding motion upon each other; this is greatest between the Astragal and Heel-bone, where the articular surfaces, though flat, are convex from side to side—the convexity of the hinder one facing upwards, and of the front one downwards. The exception is in the ball-and-socket-joint of the Astragal, Heel, and Navicular bones, in which there is very considerable rotatory motion, especially inwards, so that the Sole of the Foot can be made to face nearly directly inwards, its outer edge only resting on the ground. Slight flexion and extension of the fore part of the foot is also performed at this joint; but these are the most restricted motions.



### *Junction of the Tarsal and Metatarsal Bones, and of the latter with each other.*

The Cuneiform and Cuboid bones are connected by flat surfaces, admitting of a little motion, to the bases of the Metatarsal bones, which are strengthened by short Dorsal and Plantar Ligaments; of the latter, that between the Inner Cuneiform and the First Metatarsal, and that between the Cuboid and last or Outer Metatarsal, are the broadest and strongest, as they complete the sustentation of the Tarsal Arch from before to behind. But there is another contrivance by which the Tarsus and Metatarsus are connected, viz., by the mortise and tenon of the Cuneiform and Second Metatarsal bones; *capsular* ligaments connect the sides of the tenon of the latter with those of the mortise of the former, and the tenon is prevented splaying open the mortise below by a strong *oblique ligament*, which, arising from the outside of the Inner Cuneiform, passes beneath the base of the Metatarsal bone, is connected with it, and continued outwards and forwards to be joined to the under and fore part of the Outer Cuneiform and the base of the Third Metatarsal. The Outer Cuneiform bone extending further forwards than the base of the second, and considerably before that of Fourth Metatarsal, forms a second tenon in the opposite direction to that just described, and is received between the mortise formed by those Metatarsal bones; it has no oblique ligament, but rests upon a long ligamentous band, the *Cuboido-metatarsal Ligament*, which, arising from the back and under part of the Cuboid, passes below its groove, and is attached to the outer Cuneiform and the bases of the third and fourth Metatarsal bones.

The bases of the Metatarsus are connected by plane surfaces and *Capsular Ligaments*, and strengthened below by *Plantar* bands, which pass from the base of one to the other.

### *Junction of the Metatarsal Bones and Toes, and of the Phalanges of the latter.*

These are all hinge or rather pulley joints; each is included in a *Capsular Ligament*, strengthened on each side by a short band passing from one bone to the other, and called *Inner and Outer Lateral Ligaments*. All the Metatarso-phalangeal joints are also connected by a *Transverse ligament*, which, passing from the outer edge of the fifth runs beneath the Capsular ligaments of all except the first Metatarsal to the outer Sesamoid bone of which it is attached. Flexion, extension, and lateral inclination can be performed in all this row of joints, though the latter is much restricted by our habit of wearing shoes; but in the remaining joints flexion and extension are the only motions.

### B.—Of the Upper Limbs, or passive Prehensile Organs.

*Extremitates Superiores*, Lat.; *die Oberen Extremitäten, oder Brustglieder*, Germ.; *les Membres Supérieurs*, Fr. (Anat. Pl. IV., fig. XX to XXXVII.)

The Upper Limbs consist of the Shoulder, Upper Arm, Fore Arm, and Hand-bones, and are distinguished from the Lower by the smaller size and more

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 delicate form which their more movable functions require.

1. The Shoulder or Shoulder Girdle (*Ossa Humeri*, Lat.; *die Schulterknocken*, Germ.; *les Os de l'Epaule*, Fr.)

Consist on either side of two bones, the Collar-bone and the Blade-bone, which join together at an angle, strictly called the Shoulder; whilst by the former only they have a jointed connexion with the Trunk.

a. The Collar-bone or Clavicle (*Clavicula*, Lat.; *die Schlussel-bein*, Germ.; *la Clavicule*, Fr.) (Fig. xx.)

Is placed horizontally at the bottom of the Neck, which it separates from the Chest, having at its inner end the Breast-bone, and at its outer the Blade bone. It assumes its technical name from its resemblance to an antique key, being similar to an Italic *f* placed horizontally; its inner extremity (a.) is large, irregularly rounded, and has upon it a *flattened articular surface*, by which it is connected with the Breast-bone; upon its under surface, and about an inch from this extremity, is a rough surface called the *rhomboid process*; the *body* (c.) of the bone, or all that part between its ends, is rounded above, flattened beneath, at first curves forwards from the inner extremity, then backwards and again forwards at the outer end, which is much flattened from above downwards, expanded from before to behind, has about an inch from its tip, on the under surface, a projection called the *tubercle* (d.), and upon its extreme outer and back part a small *flat articular surface* for the Blade-bone.

b. The Shoulder-blade (*Scapula*, Lat.; *das Schulterblatt*, Germ.; *l'Omoplate*, Fr.) (Fig. xxi., xxi.*, xxi.**)

Is placed at the hinder upper part of the Chest, which, by its large expansion, it covers like a shield, where least capable of other protection.

It is a thin expanded bone, of an irregular triangular form; the *base* (a. b. c.) parallel to the ridge of the Spine of the back, and the other two *edges*, named from their position, *upper* (b. l.) and *lower* (c. d.); the former nearly horizontal and the latter diagonal; the upper (b.) and lower (c.) extremities of the base are called the *upper* and *lower angles*, and the junction of the upper and lower edges the *outer angle* (d.), which is the most important of the three, as having upon it a large shallow oval articular surface, the *glenoid cavity* (d.), facing outwards; the long axis of which is from above to below, and receives upon it the head of the Upper Arm-bone; immediately to the inner side of this cavity a contraction of the bone forms its *neck* (e.), and from its fore and upper part a strong process somewhat resembling a crow's beak, and hence called the *coracoid process* (f.), curves forwards and outwards beyond the articular surface so as to protect it in front. The fore surface of the bone, called its *belly* (g.), is slightly hollowed and marked by muscular ridges; the hind surface or back is correspondently convex, and divided into *two unequal pits* by a strong projecting process called the *spine* (h.), which commences from the base about an inch below its upper angle, increases in depth as it ascends towards the neck, where its connexion with the body of the bone ceases, but it continues outwards curving over the top of the glenoid cavity, and expanded horizontally to form a large flat process called the point of the Shoulder or *acromion* (i.), on the front of which is a small articular surface for the Collar-bone. Of the two pits formed by the upraised spine, the upper (j.) is the *supra-spinal*, and the lower (k.) is the *infra-spinal pit*. At the root of the coracoid process, and in the upper edge, is a small *notch* (l.) for the transmission of an artery, and the space between the upper edge of the glenoid cavity and the root of the acromion, which serves the same purpose, is described as a second *notch*. 

*Of the Joints of the Shoulder-bones.*

These consist of two, the *first* by which the Collar-bones are connected to the Chest and to each other, the *second* between the Collar and Blade bones; the latter of which, by this junction, are linked on to the Trunk.

1st. The *Sterno-clavicular Joint*.—The inner or sternal end of the Collar-bone, of which the articular surface is nearly flat, is connected with the concave surface at the upper corner of the first piece of the Breast-bone by means of a ligamentous capsule, the interior of which is divided into two distinct cavities lined with synovial membrane, and therefore true joints, by a *cartilage* called, from its situation, *Inter-articular*, and hollowed on both sides, an articular structure always existing where great extent and variety of motion is performed. This joint is further strengthened by some fibrous bands called the *Inter-clavicular ligament*, which, passing across the top of the Breast-bone, and connected with it, spread out on either side upon the inner ends of the two Collar-bones, the under surfaces of which are also tied to the first pair of Ribs by a pair of ligaments called the *Rhomboid* or *Costo-clavicular*, which pass from those bones to the rhomboid processes.

2nd. The *Acromio-clavicular Joint*, formed by the junction of the outer or Scapular end of the Clavicle with the Acromion by the articular surfaces already mentioned, is sometimes a true joint with cartilage covering those surfaces, included in a ligamentous capsule, and lined with synovial membrane; but more frequently the two bones are merely connected by a ligamento-cartilaginous structure, which is sufficient for the purpose, as there is no motion beyond a slight yielding between them. The connexion of these bones is further strengthened by two short strong ligamentous bands springing from the root of the Coracoid process, and named according to their connexion *Coraco-clavicular*, or in relation to their form, the anterior, the *Trapezoid*, and the posterior, the *Conoid*.

There are also some ligaments proper to the Blade-bone itself: the principal of these is a very broad and strong triangular one, which, springing from the whole upper surface of the coracoid process, passes outwards and upwards to be attached to the fore under and outer part of the acromion; its use is to protect the front of the shoulder-joint, which it does very efficiently; it is called from its form *Triangular*, or from the parts which it connects *Coraco-Acromial*. From the root of the coracoid process passes inwards across the notch in the upper edge of the Blade-bone a narrow band of stout ligamentous fibres, which render it a perfect hole; and there is often described as running from the root of the acromion to the upper edge of the glenoid cavity, another, the *Acromio-Glenoid Ligament*, the assumed use of which is to brace up that part of the bone; it is not, however, really ligamentous, but merely a small quantity of cellular tissue, beneath which passes a

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branch of the Subscapular artery, and is not of sufficient strength to afford any support to the glenoid cavity.

The junction of the Collar and Blade bones with each other, and of the former with the Breast-bone, has some analogy to the bony ring of the pelvis, the Breast and Collar bones corresponding to the Pubic portion, and the Blade-bones to the Iliac portion; but it differs in being imperfect behind, and in not being connected with the Spine except by muscle: the reason for which is, that in the Shoulder motion is required, in the Basin solidity and strength.

The apparatus for Motion at the Shoulder, so far as it is at present to be considered, relates to keeping the Socket of the Shoulder-joint at such distance from the Trunk that the motions of the Arm upon it may not be interfered with. For this purpose is the Collar-bone formed and interposed between the Breast and Blade bone; and though it is capable of performing elevation, depression, and horizontal motion forwards and backwards upon the Breast-bone, yet however powerful the muscular action, the glenoid cavity can never be drawn so near to the Chest as to interfere with the motions of the Arm. Without the Clavicle to keep it off, the Blade-bone would, instead of being situated upon the back of the Chest, as it is in all animals which have a Clavicle, rest against the side of the Chest, and the Arm could not be carried across the body and raised to the mouth, nor could it be abducted or raised from the side of the Trunk: its motions would be confined simply to swinging backwards and forwards, as they are in all those Animals in which this bone is deficient, and in which the Fore Limbs, as the upper are then called, are mere progressors upon the ground. But when these Limbs are partially locomotive and partially prehensile, there always exists a Collar-bone more or less fully developed according to the variety and power of the prehensile actions, of which ample examples are given in the Essay on ZOOLOGY.

2. THE UPPER ARM (*Brachium*, Lat.; *die Oberarm*, Germ.; *le Bras*, Fr.) (Fig. XXII.)

Consists of a single bone.

The Upper Arm-bone (*Os Brachii*, Lat.; *die Oberarmbein*, Germ.; *l' Humerus*, Fr.).

This depends from the Glenoid cavity upon the side of the Chest, and extends between the Shoulder and Elbow Joints.

It is of an irregularly twisted cylindrical shape; its upper end has a large rounded articular surface facing upwards, inwards, and rather backwards, forming a considerable portion of a sphere, and called the *head* (a.), to the outer and fore part of which are two knobs (b. c.), separated from each other by a *groove* for the passage of a tendon, and called *tubercles*, of which the outer is the larger; just below these, a contraction of the circumference of the bone is called its *neck* (d.), and thence to the lower end the shaft, which is of a somewhat triangular and twisted form, is called the *body* (e.), marked on the outer upper part by a rough surface for muscular attachment, and by the continuance of the groove which had commenced between the tubercles, bounded by two ridges. The lower end of the bone expands laterally, is nearly flat behind and rounded laterally in front, and is terminated below by two lateral projections called *condyles* (f. g.), of which the inner (f.) is most developed, and has behind it a vertical pit for the passage of a nerve; between the condyles is a *double pulley-like articular surface* (i.): the *outer* portion of this surface is nearly hemispherical and the smaller of the two, but the *inner* is convex from before to behind, and concave from side to side, with a shallow pit above it before and a deep one behind.



*Of the Shoulder-Joint.*

The Shoulder-Joint is, next to the Hip, the most perfect ball-and-socket-joint in the body, but differs from it in its shallowness, which allows greater extent and complication of motion. The rounded head of the Upper Arm-bone rests upon the shallow glenoid cavity, which is deepened by a circular ligamentous ring at its margin, called the *Glenoid Ligament*, around which extends from the neck of the Blade-bone, over the head of the Upper Arm-bone, a very loose ligamentous bag, called the *capsular ligament* (b.), which, however, does not bring the bony surfaces into immediate contact: this is effected by means of one of the tendons (c.) of the Biceps flexor cubiti-muscle, which, originating from the upper edge of the glenoid cavity, passes over the head of the Arm-bone, and through the Capsular ligament between the tubercles to join its muscular part; but it is external to the joint even whilst within the capsule, the synovial membrane which lines the capsular ligament and covers the articular cartilaginous surfaces of the bones being reflected on it. This tendon corresponds in function to the round ligament of the hip-joint, but in consequence of the greater length of the capsular ligament, a large extent and greater freedom of action is allowed in this joint than could be admitted were the two ends of the connecting tendon permanently fixed, as are those of the round ligament of the hip. No loss of strength, however, accrues from this formation; for in proportion as the hand is weighted this muscle in endeavouring to raise it acts from both its extremities, and whilst thus operating on the Fore Arm approximates the head of the Upper Arm-bone more closely to the glenoid cavity, and strengthens the joint. Another ligament of the Shoulder-Joint, the *Coraco-Acromial* (a.), belongs only to the scapula, passing from its coracoid to its acromial process; but it is of great importance as protecting and strengthening the front of the Shoulder-Joint, so that the head of the Arm-bone cannot be driven upwards and forwards out of the shallow socket.

The Shoulder-joint is protected from injury above by the acromion, which almost completely overhangs it, and in front by the coracoid process; so that it is only exposed on the outer and back part, where, however, it is defended by the large mass of muscles covering it and moving the Arm, the tendinous expansions of some of which are intimately blended with and strengthen the ligamentous capsule itself.

The motions performed at the Shoulder-joint consist of procession and retrocession, and their successive alternations, a swinging motion; also of abduction and adduction, or elevation and depression; a rotatory motion when all these four movements are successive, the elbow-joint describing the periphery of a large circle, whilst the head of the Upper Arm-bone moves only upon the glenoid cavity, with little actual change of position, just as a stone attached to a string held in the hand and whirled round moves. When the Arm is upheld

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in the horizontal posture, the elbow and fore arm can be brought forward or carried backwards. And when it hangs to the side, a rotatory motion upon the glenoid cavity, similar to that of a spindle, can be performed. From this enumeration it will be easily imagined that the capability of motion at this joint is very great, and the possible combinations of motion almost innumerable.

The ordinary movements of the Arm are performed on the Glenoid cavity, as the fixed point; but when more violent exertion is required, as in pulling, throwing, striking, &c., the whole Shoulder, *i. e.*, the Collar and Blade bone, participate in the motion by the swinging of the sternal end of the Clavicle upon the sterno-clavicular articulation.

3. The Fore Arm (*Antibrachium*, Lat.; *die Vorderarm*, Germ.; *l'Avant-bras*, Fr.) (Figs. XXIII. XXIV.)

Is all that part of the Upper Extremity between the Elbow and Wrist Joints; it consists of two bones.

a. The Cubit (*Ulna*, Lat.; *die Ellenbogenrohre*, Germ.; *le Cubitus*, Fr.) (Fig. XXIII.)

Is placed on the inner side of the Fore Arm, which it specially connects with the Upper. It is of an irregular triangular shape, except at its lower part, which is rounded; the upper end is the larger, and has on its fore and top part a large semicircular articular cavity called the *sigmoid* (a.), divided by a middle vertical *ridge*, and corresponding to the inner pulley-like articular surface of the Upper Arm-bone, into which it fits; this is bounded above by a strong process, called the *olecranon* (b.), or point of the Elbow which projects backwards when the Fore Arm is bent, but drops into the deep cavity behind the pulley-like surface of the upper bone when straightened; on its back is a smooth surface called the *ancon*, or true elbow; below, the cavity is bounded by the *coronoid process* (c.), which is merely its prominent lip; on the outer side of this cavity is another smaller one, semilunar and horizontal, called the *lesser sigmoid* (e.), in which is received the side of the head of the Spoke-bone; below the coronoid is a rough surface called the *tubercle;* the *body* or shaft (f.) of the bone is nearly prismatic, the base facing inwards, and its angles rounded, the apex outwards, sharp and thin, for ligamentous attachment; the lower end or *base* (h.) has a *rounded articular surface* (g.) on its outer and fore part for the Spoke-bone, and is elongated on the inner and under part by a little stud called the *styloid process* (i.).

b. The Spoke-bone (*Radius*, Lat.; *die Speiche*, Germ.; *le Radius*, Fr.) (Fig. XXIV.)

Is situated on the outer side of the Fore Arm, extending between the Elbow and Wrist Joints. Its general form resembles that of a wheel spoke, whence it derives its name. It is of a prismatic figure, smaller and of more rounded form above than below; its top or *head* (a.) is rounded, and has upon it a *cup-like articular surface* for the reception of the outer articular surface of the Upper Arm-bone; around its inner and fore part is a *narrow smooth articular surface*, which is received into the lesser sigmoid cavity of the Cubit; below it a contraction of the bone forms its *neck*, beneath which, on the fore and inner part, is the *tubercle* (b.). The shaft or *body* (c.) of the Spoke-bone increases in bulk as it descends, the base of the prism facing outwards with its angles rounded, whilst the third angle is sharp for ligamentous attachment. The lower end of the bone is very wide, and called its *base* (d.); it has an *articular surface* below, concave from before to behind, divided by a middle ridge, and concave from side to side for the reception of the outer two upper Carpal bones; upon its outer edge it is slightly elongated, forming its *styloid process* (e.); upon the inside of the base is a shallow *semilunar cavity*, by which it rolls upon the lower end of the Cubit; the front of the base is smooth, but its outer and back part marked by *vertical grooves* for the passage of tendons.



*Of the Elbow-Joint.* (Fig. XXV.)

The Upper Arm-bone, with the Cubit and Spoke bone, form this joint; all their articular surfaces, covered with cartilage, are enveloped in a synovial bag, which is strengthened by ligamentous bands passing in various directions from the Upper to the Fore Arm; these, according to their position, are called *Anterior* (a.) and *Posterior Ligaments*, but more commonly considered as a single one, and named *Capsular*; it is strongest in front and weakest behind, where it is strengthened by the large Extensor Muscle of the arm. On each side of the joint a ligament passes from the condyle to the Cubit on the inner, and to the Spoke-bone on the outer side; the former, the *Internal Lateral* (b.), is of a triangular shape, narrow above and wide below, where connected with the inner edge of the great sigmoid cavity; the latter is narrow and cord-like, the *Outer Lateral* (c.), and attached to the coronary ligament of the Spoke-bone.

The junction of these bones with that of the Upper Arm form merely a simple hinge-joint, flexion and extension being the only motions of which the Cubit (which, with the Upper Arm-bone, truly forms the Elbow-Joint) is capable; for when the Fore Arm is bent the coronoid process of the Cubit is received into the pit above and before the condyles; and when straightened, the olecranon process of the former locks into the deep pit above and behind the condyles.

*Of the Fore Arm-Joints.* (Figs. XXV. XXVI.)

As already stated, the Fore Arm consists of two bones, the Cubit and Spoke bone, which, however, although connected so as to form only a single limb, yet present some remarkable points in their junction, arising out of the necessity for the motion of one bone upon the other, so as to allow certain motions of the Hand.

So far as their junction with each other is concerned, they are united by an expansion of ligamentous fibres passing from the outer angle of the Cubit to the inner angle of the Spoke bone, throughout their whole length, which is called the *Interosseous Ligament;* one aperture is left at the upper, and another at the lower part of this ligament, for the passage of vessels and nerves; and a narrow slip of it at the upper part, which passes from the tubercle of the Cubit to the lower part of the tubercle of the Spoke bone, is called the *Oblique Ligament* (d.). By these the two bones are so firmly connected, that for actual use they may be considered as a single bone.

The mechanism by which the Spoke-bone moves round the base of the Cubit to perform pronation and supination of the Hand, consists in a ligamentous collar, which is called the *Coronary Ligament* (e.), sur-

rounding the neck of the Spoke-bone, and attached immediately beneath the less sigmoid cavity of the Cubit, confining the head of the Spoke-bone in that cavity, and therefore compelling it to perform only a rotatory motion, like that of a pivot in its socket. The lower end of the Spoke-bone is, however, very differently circumstanced, as it travels round the base of the Cubit describing a semicircle; this is effected by the concavity and convexity being reversed; at the upper end the concavity is on the Cubit, and the convexity on the Spoke bone, but at the lower end the latter is concave and the former convex; the lower end of the Cubit is enveloped in a loose, bag-like ligament, hence called the *Sacciform Ligament*, which includes the concavity on the inside of the base of the Spoke-bone, and is attached below to an irregularly circular cartilage, called the *Inter-articular*, from being interposed between the Cubit and the Wrist-joint, and attached to the inner edge of the base of the Spoke-bone. In consequence of this disposition of the articular surfaces, and the mode in which the bones are connected by a ligament at their two extremities, any rotation of the head of the Spoke-bone, in the less sigmoid cavity, causes correspondent circumduction of its base upon the base of the Cubit; and as the band is specially connected with the Spoke-bone, as will be presently shown, it is rendered prone by the rotation inwards of the head of that bone, and supine by its rotation outwards, whilst the extent of these motions, in either case, is bounded by the oblique ligament which acts as a check. It is also to be observed that these motions, viz., pronation and supination of the Hand, can be performed, in whatever state of flexion the Fore Arm is, upon the Upper Arm, in consequence of the cup of the Spoke-bone always retaining the same position in regard to the upper end of the Cubit. The common and natural position of the Fore Arm, when hanging down and relaxed, is intermediate between pronation and supination, the styloid process of the Spoke-bone being directed forwards, but in Anatomical description the Fore Arm is always considered supine, and the palm of the Hand consequently facing forwards.

4. The Hand (*Manus*, Lat.; *die Hand*, Germ; *le Main*, Fr.) (Fig. XXVII. to XXXVII.)

The Hand is placed below the Fore Arm, especially connected with the Spoke-bone, and consists of the Wrist, the Mid-hand, and the Fingers.

a. The Wrist, or Carpal Bones (*Ossa Carpi, seu Carpus*, Lat.; *die Handwurzel*, Germ.; *le Carpe*, Fr.) (Figs. XXVII. to XXXIV.),

Consists of eight small bones disposed in two rows, together forming an arch, the span of which is lateral, its concavity forwards and its convexity backwards. Their fore and hind surfaces are generally rough, but their sides and ends form smooth articular surfaces. In form they vary considerably from each other, and are named accordingly. Six of them have four articular surfaces, another six, and the remaining one a single articular surface.

In the first, or upper row, commencing from the outer, they are thus ranged:—

1. The Scaphoid Bone (*Os Scaphoides*, Lat.; *das Schiff, oder Kahn-bein*, Germ.; *le Scaphoïde*, Fr.) (Fig. XXVII.).

In shape this resembles a boat, the convexity or bottom of which faces upwards and outwards. Upon the outside and above, is a large convex articular surface for the Spoke-bone, and below another for the outer two Carpal bones of the second row; above and on the inner side is a semilunar flat surface for the Lunar bone, and below it a concave surface, forming part of the socket for the head of the Great Bone.



2. The Lunar Bone (*Os Lunare*, Lat.; *das Mond-bein*, Germ.; *le Semi-lunaire*, Fr.) (Fig. XXVIII.),

Placed to the inner side of the preceding; of a semilunar form, with its convexity upwards. On its upper part it has a large convex surface for the Spoke-bone; below, a concave one to complete the cup for the head of the Great Bone, on the outside a semilunar one for the Scaphoid, and on the inner a squarish one for the Cuneiform Bone.

3. The Cuneiform Bone (*Os Cuneiforme, seu Triquetrum*. Lat.; *das Dreieckige, oder Dreisitige-bein*, Germ.; *le Pyramidal*, Fr.) (Fig. XXIX.)

Is the innermost of the first row, and of an irregular wedge-shape, with its base connected to the last described bone. The upper end has an articular surface, scarcely deserving that name, by which it joins the inter-articular cartilage; below, it has an articular surface for the Unciform; on the outer side or base, one for the Lunar, and in front another for the Pisiform.

4. The Pisiform or Pea-bone (*Os Pisiforme*, Lat.; *das Erbsen-bein*, Germ.; *le Pisiforme*, Fr.) (Fig. XXX.)

Is placed on the front of the last bone, and in appearance resembles a split pea, the diametral surface of which being its only articular one, is for the Cuneiform.

In the second row there are also four bones, viz.—

5. The Trapezial Bone (*Os Trapezium, seu Multangulum Majus*, Lat.; *das Grosse Vieleckige-bein*, Germ.; *le Trapèze*, Fr.) (Fig. XXXI.),

Which is the outermost, and of an irregular trapezial figure, and it has in front a vertical groove for the passage of a tendon. At the top it has a slightly concave articular surface for the Scaphoid; below, a small one for part of the Metacarpal bone of the Fore Finger; on the outer side, a large articular surface, concave from above downwards, and convex from before to behind, for the Metacarpal bone of the Thumb, and on the inside a nearly flat surface for the Trapezoid Bone.

6. The Trapezoid Bone (*Os Trapezoides, seu Multangulum Minus*, Lat.; *das Kleine Vieleckige-bein*, Germ.; *le Trapèzoide*, Fr.) (Fig. XXIII.),

Placed on the inside of the preceding, resembling a truncated square nail, the head of which faces backwards. It has a slightly concave articular surface above for the Scaphoid; below, another for the Metacarpal bone of the Fore Finger; one on the outer side for the Trapezial, and another on the inner side for the Great Bone.

7. The Great Bone (*Os Magnum, seu Capitatum*, Lat.; *das Grosse, oder Kopf-bein*, Germ.; *le Grand Os*, Fr.) (Fig. XXXIII.)

Placed to the inner side of the preceding, and the

Anatomy. largest of the Wrist bones, is of an irregular wedge shape, with its base behind, and having on its upper end a large rounded *head*. It has six articular surfaces: above, one, the head, which is received into the cup of the Scaphoid and Lunar Bones; below, three, the middle one the largest, for the Middle Metacarpal; the outer the smallest, to join with the fore Metacarpal, and the innermost rests upon the Ring Metacarpal bone; upon the outside there is a plane one for the Trapezoid, and on the inside a similar one for the Unciform Bone.

8. The Unciform Bone (*Os Unciforme, seu Hamatum*, Lat.; *das Haken-bein*, Germ.; *l'Os Crochu, ou Unciforme*, Fr.) (Fig. xxxiv.)

Is the innermost of the second row, and distinguished by the *hook-like projection* which stands forward from the inner and fore parts of the bone. Its upper end slopes downwards, and is connected with the Cuneiform; its lower end has two articular surfaces, divided by a middle ridge, for part of the Ring and for the whole of the Little Metacarpal Bone, and on its outside is a flat surface for the Great Bone.

The articular surfaces just described as belonging to the several Carpal Bones indicate their junctions, and being generally flat admit of little more than a gliding motion upon each, not excepting even the ball-and-socket-joint formed by the Great, the Scaphoid, and Lunar Bones, which does not appear intended for motion, but rather as the means of connecting more perfectly the two rows of the Wrist-bones, and preventing their dislocation horizontally from each other.

Together they form an arch, the concavity of which is directed forwards, and through which the flexor tendons of the fingers pass into the hand; and when the wrist is rested on a table with the palm downwards, the bases of the piers on which it stands are, on the outer side, the Scaphoid and Trapezial, and on the inner the Pisiform and Unciform Bones.

### *Of the Wrist-Joint.*

The Wrist-Joint is one of those which are called Ball-and-socket-joints, the socket being formed by the base of the Spoke-bone and the under surface of the inter-articular cartilage already mentioned (p. 406), and the ball by the Scaphoid, Lunar, and part of the Cuneiform Bone; the latter is not, however, the segment of a sphere, but of an ellipsis, the long axis of which is from side to side; the socket is very shallow, and corresponds to the ball or ellipsis. The Carpus, taken as a whole, is connected to the Spoke-bone and to the inter-articular cartilage by very strong ligamentous bands, called the *Anterior* and *Posterior* or *Capsular Ligament* of the Wrist, which pass especially from the Spoke-bone to the upper row of the Carpus; and these are of sufficient length to allow the Hand to be flexed upon the Fore Arm to a right angle, and to be extended upon it almost to the same extent. In addition to these, there is on each side a strong ligamentous cord passing between them; that on the outer side, extending from the styloid process of the Spoke-bone to the Scaphoid, is called the *Outer Lateral* or *Radio-Carpal Ligament*; and that on the inside, from the styloid process of the Cubit to the Cuneiform and Pisiform Bones, is the *Inner Lateral* or *Cubito-Carpal Ligament*.

The motions of the Wrist-Joint in reference to the Spoke-bone are flexion and extension, as already stated, and also adduction and abduction, or inclination of the inner or outer side of the Hand to the corresponding sides of the Fore Arm; the motions of the Hand being also still further increased by the consecutive performance of flexion, adduction, extension, and ebduction, by means of which the points of the fingers are capable of applying themselves to any point of a circle of a certain diameter, or to any part within its periphery. The extent of this circumduction is also further increased by the semicircular movement of the base of the Spoke-bone around the lower end of the Cubit. Thus is shown the first part of the mechanical arrangement by which the delicate and complicated motions of the Hand are performed, the remainder of which will be seen after considering the bony structure of the Fingers. Anatomy.

### *Of the Carpal Joints.*

The Wrist-Bones are connected to each other by ligamentous slips passing in almost every direction upon their fore and hind surfaces, and hence called *Palmar* and *Dorsal Ligaments*; besides which there are others, very short, passing from the side of one bone to that of another, in such parts as have no articular surfaces, and called from their position *Interosseal*, of which those of the second row are the most extended, though equally short with the upper, and admitting of very slight sliding motion of the bones upon each other. The junction of the Pisiform with the Cuneiform Bone is distinguished from the others in being effected by a proper *Capsular Ligament*. As the upper row of Carpal bones form the ball of the Wrist-Joint already mentioned, so does the head of the Great Bone form the ball which is received into the socket of the first row, consisting of the Scaphoid and Lunar Bones; but there is no distinct capsular joint, and the whole connexion of the upper with the lower row of the Carpus leaves one common joint between all the articular surfaces entering into it. The separation of the sides of the Carpal Bones from each other is also mainly prevented by the strong ligamentous band, the *Anterior Ligament of the Wrist-Joint*, which passes from the Pisiform and Unciform bones on the inner, to the Scaphoid and Trapezial bones on the outer side, and connects the piers of the arch so as to prevent them splaying out when a violent blow is received upon the back of the wrist or crown of the arch, the part where such violence is commonly received, and where it would be most severely felt were it not for this connexion of the two piers of the Carpal Arch. This ligament, together with the Carpal Arch, forms a ring through which the flexor tendons pass into the Palm, and are prevented starting from their place on violent flexion of the fingers; and when the Hand is flexed upon the Arm, it serves the further purpose of a pulley-wheel, over which the same tendons perform their actions.

b. The Mid-hand Bones (*Ossa Metacarpi, seu Metacarpus*, Lat.; *die Mittelhand*, Germ.; *le Métacarpe*, Fr.) (Fig. xxxv.)

Consist of five irregularly cylindrical bones placed between the Carpal Arch above and the fingers below, and corresponding with the Mid foot, but differ in being shorter and comparatively stronger, excepting the bone belonging to the Thumb, which is smaller than the corresponding one of the Great Toe, and is further distinguished by being movable upon the Carpus, whilst the Great Toe is immovable on the



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Tarsus. The inner four Mid-hand Bones belong to the Fingers, and, like the Fore Arm, face backwards and forwards; the outer one, which forms part of the Thumb, faces inwards and outwards. All five have *bases* or upper, *bodies* or middle, and *heads* or lower parts; but those belonging to the Fingers differ materially from that of the Thumb, and in a less degree from each other.

The *bases* of those belonging to the Fingers are mostly of a triangular form, the base of the triangle facing backwards and its apex forwards, and each has upon it articular surfaces for junction with the Wrist-bones. The *first*, which belongs to the Fore finger, has on its outer edge a small articular surface corresponding to one on the Trapezial bone, a large one in the middle for the Trapezoid, and on the inner side one for the Great bone. The *second*, which supports the Middle finger, has one large surface for the principal surface on the Great bone. The *third*, connected with the Ring-finger, has on its outer side a small one for part of the Great bone, and on its inner a large one for part of the Unciform bone: and the *fourth*, which joins the Little finger, has a large one for the remainder of the Unciform bone. All these surfaces and their correspondents are nearly flat, and preclude more than a slight yielding motion similar to that between the Wrist-bones; and as they are closely approximated, the corresponding sides of the bases have small articular surfaces for each other.

The front surfaces of the *bodies* of these bones are sharp and keel-shaped, as they are also at their back near the base; but towards the heads they are expanded behind, so that they there assume a prismatic form.

The *heads* are rounded from before to behind and from side to side, more in the former than in the latter direction, and on each side, above the articular surfaces on the head, is a little depression in which ligaments are fixed.

The bone belonging to the Thumb is shorter than the others, is flat within and convex from before to behind without: its *base* differs from that of the others in having such form, that is, an articular surface concave from without to within, and convex from before to behind, as allows a double hinge-motion; viz.—from before to behind, and from within to without, upon the Trapezial bone: its *body* is nearly flat without, and convex before to behind within: its *head* has a broad articular surface commencing only from the end of the shaft, and slightly rounded inwards.

### *Junction of the Wrist and Mid hand.*

The junction of the inner four bones of the Mid hand with the second row of the Wrist-bones being by flat or nearly flat surfaces, and no more than slight yielding motion being performed between them, they are connected on the back and front by short flat ligaments, and included in a common synovial capsule. The Thumb-bone, however, is connected to the Trapezial by a distinct loose capsular ligament and synovial membrane, so that motion can be performed on the latter bone in any direction, as flexion or drawing the thumb across the Palm, extension or carrying it outwards, adduction or bringing it to the Fore finger, abduction or carrying it forwards from the Palm, or a successive alternation of these motions, by which circumduction is effected, in which the base of the bone is moving upon the small space formed by the articular surface of the Trapezial bone, whilst the head describes a comparatively large circle.



c. The Fingers (*Phalanges Digitorum Manus*, Lat.; *die Finger-glieder*, Germ.; *les Doigts*, Fr.) (Figs XXXVI., XXXVII.).

The four Fingers and the Thumb consist together of fourteen bones, ranged in three rows to the former and two to the latter, corresponding to the rows of the Toe-joints, but differing from them in their greater length and strength, except as relates to the Thumb and the Great Toe. They are situated immediately below the Mid hand. The first two rows of the Phalanges or Joints of the Fingers (fig. XXXVI.), as they are indiscriminately called, have a general resemblance in having their *bodies* rounded behind from side to side and flattened in front. The upper ends or *bases* (a.) of the first row are shallow cups, received on but not completely covering the heads of the Mid-hand bones; their lower ends or *heads* (b.) are convex from before to behind, the articular surfaces extending further forwards than behind, and concave from side to side, corresponding with the lateral depressions and middle convexity on the base of each bone of the second row. The second row are shorter than the first: their *bases* (a.) have been just spoken of; their *heads* (b.) are similar to those of the first row, and correspond with the bases of the third row. The third row are the shortest of all; their *bases* are similar to those of the second; instead of heads their lower ends or *tips* (b.) are much flattened, and spread out somewhat like the bowl of a spoon, to give greater breadth behind for the attachment of the nails, hence they are called the Nail-joints, and to enlarge in front the space upon which the extreme branches of the nerves of Touch are expanded.

The Thumb (fig. XXXVII.) has but two rows correspondent with the first and third of the Fingers, but which are larger; the *base* of the upper one is shallow and concave from within to without; the *base* of the lower similar to that of the Fingers.

At the base of the first joint of the Thumb, and also at that of the Little Finger, a pair of small bones called Sesamoid are frequently found.

### *Joints of the Fingers and Thumb with the Mid hand, and of the rows of the former with each other.*

All the bones of the Fingers and Thumb are connected with each other and with the Mid hand by capsular ligaments lined with synovial membrane: those connecting the first row of the Fingers to the Mid hand by capsular ligaments only, which allow of their flexion forwards at right angles with the Palm of the Hand, and when extended to the same plane as its back, which they cannot exceed, admit of slight lateral motion. The other rows of the Fingers, however, together with the junction of the upper bone of the Thumb above, to its Mid-hand bone, and below to the second row, are strengthened on the lateral parts of the former, and on the fore and back parts of the latter, by narrow flat, or, as they are commonly called, *lateral* ligaments, which preclude any lateral motion; and thus the movements of the finger-joints upon each other, and of the thumb upon itself, and on its Mid-hand bone, are merely flexion and extension, or a hinge-motion.

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# ANATOMY.

## SECTION II.

### OF THE MUSCLES.



The variety in form and attachment of Muscles having been already treated of in the Essay on ZOOLOGY, p. 175, their arrangement on the Human Subject is now to be considered. The disposition of the Muscles upon the skeleton is not simply for locomotion and for the movement of its several parts upon each other, but also for the bracing up and support, either in the erect or in any particular position, of the whole skeleton or any of its pieces; and, in the latter case, to furnish fixed points upon which neighbouring bones, either above or below, may be moved. Thus, though the Muscles of the lower limbs sustain their erect posture, and also that of the whole trunk, the Muscles of the foot and leg may retain the leg upright, whilst those connecting the latter with the thigh can bend and again extend that part of the lower limb upon it; or the same Muscles which have performed these motions can fix the leg in any position upon the thigh, whilst the Muscles of the foot are left free to move it upon the leg. Hence it appears that all Muscles attached to parts movable on each other are capable of assuming either as the fixed point from which the motion is commenced; the terms origin and insertion therefore do not really determine always, though generally, which is the fixed and which the moving attachment. This variation of the fulcrum, and the less or greater contraction of a Muscle, by which its attachments are less or more approximated, together with the concurrent, successive, or alternate actions of many Muscles connecting the same parts, though but little distant from each other, are the cause of the delicate and almost innumerable variety of motions performed by many parts of the body, of which those of the hand are the most remarkable, excepting those which influence the soft parts of the face, and make of it a book on which are inscribed the varied passions of the mind.

It is a difficult matter to determine where to commence the description of the Muscles, and whether to describe them as they are successively laid bare by the dissecting knife, or to class them in reference to their connexion with parts which they most generally move. The latter method has the inconvenience of occasionally having to remove Muscles not previously examined, but which are unconnected with the parts whose Muscles are under consideration; but this is of less consequence than the confusion which ensues from the former method, by which the moving powers of any particular part are indiscriminately lotted together on account of their position.

#### 1.—OF THE MUSCLES OF THE HEAD.

The Muscles of the Head are divided, 1st, into those connecting the Skull with and moving it directly upon the Trunk, of which all but one pair originate from the Spine; 2ndly, those commonly called the Muscles of the Face, including the Muscles of the Mouth, Nose, Eyes, and Auricles, and, 3rdly, the Maxillary Muscles, in connexion with which must be considered all the other Muscles attached to the Tongue-bone and Larynx, many of which by means of the Lower Jaw act indirectly upon the Skull.



##### a.—OF THE MUSCLES MOVING THE SKULL.

From the position of the Skull upon the summit of the Spine, and from the mobility of the cervical pieces of the Vertebral column, the greater number of the Muscles inserted into the Skull assist materially in the performance of the motions of the neck. Of these Muscles, seven pairs are placed on the back of the chest and neck, and four pairs upon the front of the neck, one of which arises from the top of the chest.

The *M. Trapezii*, *Rhomboidei*, and *Serrati Postici Superiores* having been removed, the *M. Splenii* are seen rising up from the top of the dorsal spine, and inclining outwards from the middle of the neck as they pass towards the occipital bone, leaving between them a space resembling that contained within the legs of the letter V, in which the *M. Complexi* are observed passing up to the back of the Skull.

*M. Splenius* (Pl. VII. xx.) is a flat Muscle which arises from the upper four dorsal and the lower five cervical spines; the fibres ascend upwards and outwards, and are inserted in two portions, the lower one by so many tendons into the transverse processes of the upper five neck vertebres, and the upper one into the back of the mastoid process of the temporal bone; the former is often called *M. Splenius Colli*, and the latter *M. Splenius Capitis*. *Use.*—When the pair of Muscles act they pull the head and neck back upon the dorsal spine; but if only one act, it inclines the head backwards and to the opposite side, and turns the face upwards.

*M. Complexus* (Pl. VII. xx.*) is so called from the large intermingling of tendinous fibres in its muscular part, one of which is so largely developed that the muscular parts with which it is connected have been named *M. Biventer Cervicis*, as if it were a distinct Muscle. The origin of this Muscle is from the transverse processes of the upper seven back vertebres, between the *M. Longissimus* and *Spinalis Dorsi*, also from the transverse processes of the under four neck vertebres by so many tendons, and from the first dorsal spine by a little fleshy belly. The Muscle increases in breadth as it ascends, and it is inserted into the space on the occipital bone between its greater and little transverse ridge. *Use.*—It draws backwards or extends the head and neck upon the back.

On the outer edge of the last is situated a thin narrow Muscle,

*M. Trachelo-mastoideus*, which originates by thin



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tendons from the transverse processes of the upper three dorsal and the lower five cervical vertebres; it ascends vertically, and is inserted into the back of the mastoid process. *Use.*—When both Muscles act they assist in steadying the head; but if one only, it sways the head to that side and backwards.

The remaining four pairs of Muscles are short Muscles, and are seen by turning off the top of the *M. Complexus;* three of them are inserted into the Skull, and the fourth acts upon it, as if it were attached to it, by its insertion into the first neck vertebre.

*M. Rectus Capitis Posticus Major* arises from the second cervical spine, expands, as it ascends, like a fan, and is inserted into the little transverse ridge of the occipital bone.

*M. Rectus Capitis Posticus Minor* is covered by the former, having its origin from the little stud on the back of the ring of the first cervical vertebre; it is inserted fleshy into the pit above the great occipital hole. *Use.*—These Muscles extend the Skull back upon the vertebres whence they arise.

*M. Obliquus Capitis Inferior* is for its size a bulky Muscle; it arises fleshy from the spine of the second cervical vertebre, runs outwards and a little upwards, to be inserted into the transverse process of the Atlas. *Use.*—It turns the Atlas round to the side from whence it arises, and with it also moves the Skull; but if both Muscles act together they steady the Skull.

*M. Obliquus Capitis Superior* arises from the transverse process of the first neck vertebre tendinous, runs upwards and inwards, and is inserted into the occipital bone close to the mastoid process of the temporal bone. *Use.*—This pair is one of those which may be called muscular ligaments; they effect but little motion of the Skull, and that is extension.

The antagonists of the seven Muscles just mentioned are, three out of the four, Muscles of small size, as the exertions they have to make are trifling, in consequence of the weight of the head preponderating in front of the spine.

*M. Rectus Capitis Anticus Major* arises tendinous and fleshy from the roots of the transverse processes of the third and three following cervical vertebres; it ascends, and is inserted into the basilar process of the occipital bone. *Use.*—It bends the Skull forwards upon the Neck, and also the upper part of the Neck upon itself.

*M. Rectus Capitis Anticus Minor* arises from the front of the ring of the first cervical vertebre, and it is inserted near the root of the condyle of the occipital bone. *Use.*—It is little more than a muscular ligament.

*M. Rectus Capitis Lateralis* arises from the transverse process of the first cervical vertebre; its short fibres pass directly upwards, and are inserted into the occipital bone behind, and to the outside of the jugular pit. *Use.*—No more than a muscular ligament.

*M. Sterno-cleido-mastoideus* (Pl. VI. n.).—This large pair of muscles, which pass from the fore part of the chest backwards and upwards behind the ears, are really the antagonists of all the extensor Muscles of the Head and Cervical Spine. It arises by a strong tendon from the front of the upper piece of the breast-bone, and from the inner upper third of the collar-bone by a fleshy origin; its fibres form a broad powerful Muscle, which runs upwards, and is inserted with tendinous fibres intermixed around the mastoid process, and from its root backwards to the lambdoidal suture. *Use.*—If both Muscles act together, they pull the head down to the chest, at the same time bending the neck; if one act, it turns the face to the opposite shoulder, and draws the head down to its own side; if the two act alternately, they assist the *M. Obliqui Posteri Inferiores* in rotating the first on the second vertebre.



b.—Of the Muscles upon the Face.

First, of those belonging to the Mouth.

These consist of nine pairs, and a single circular Muscle, made up by the coalescence of the others. Each lip is furnished with three pairs, and into the corners of the mouth are inserted three pairs.

*M. Levator Labii Superioris* (Pl. X., fig. 1. a.) arises from the front of the orbitar process of the upper jaw-bone, above the infra-orbitar pit, and it is inserted into the middle of the upper lip.

*M. Depressor Labii Superioris* is within the mouth, and is but a short small Muscle: it arises from the root of the alveolar process of the upper jaw, which supports the incisive teeth, and is inserted into the upper lip.

*M. Levator Anguli Oris* (fig. 1. b.) arises from the front of the upper jaw below the infra-orbitar pit, and is inserted into the upper lip near the corner of the mouth.

*M. Depressor Anguli Oris* (fig. 1. c.) arises from the fore and lateral part of the base of the lower jaw by a wide origin. Its fibres collect, and it passes upwards to be inserted into the lower lip near the angle of the mouth.

*M. Depressor Labii Inferioris* (fig. 1. d.) arises from the front and lateral part of the chin, partially covered by the last Muscle: it is inserted into the lower lip.

*M. Levator Labii Inferioris* is within the mouth, and arises from the alveolar process, supporting the outer incisive tooth in the lower jaw: it is inserted into the inside of the lower lip. The *Uses* of the preceding six muscles are implied in their names.

*M. Zygomaticus Major* (fig. 1. e.) is a narrow long Muscle arising from the zygomatic arch, and ascends to be inserted into the corner of the mouth.

*M. Zygomaticus Minor* (fig. 1. f.) is placed in front of the last Muscle, arising from the prominence of the cheek-bone: it is inserted into the angle of the mouth before the last. *Use.*—Both these Muscles draw up the corners of the mouth, especially in grinning.

*M. Buccinator* (fig. 1. g., IX. g.), so called from its employment by trumpeters. It is a very large Muscle, forming the lateral boundary of the mouth and cheek: it arises from the upper jaw behind the last molar tooth, and from the lower jaw at the same point; its fibres pass forwards, and are inserted into the corner of the mouth. *Use.*—Its principal function is to thrust the food between the teeth, when it has been pushed outwards by the tongue during mastication.

*M. Orbicularis Oris* (fig. 1. h.) is a circular muscle included in the red part of the lips. *Use.*—It closes, or, in common language, purses up the mouth, and it antagonizes all the nine pairs of Muscles just described.

Secondly, of the Muscles belonging to the Nose.

These are two pairs.

*M. Levator Alæ Nasi* (fig. 1. i.) arises from the nasal process of the upper jaw-bone; it descends by the side of the nose, and is inserted into the outside of its alar cartilage. *Use.*—If the pair of Muscles act, they expand the nostrils, as in sniffing.

*M. Compressor Nasi* (fig. 1. j.) arises from the root of the nasal process of the upper jaw at the under and

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outer part of the front orifice of the nostrils: its narrow band of fibres passes upwards and mounts over the cartilages just below the nasal bones, where it joins its fellow. *Use.*—It compresses the nose in snorting.

Thirdly. The Muscles belonging to each Eye and its appendages consist of ten, four of which are exterior to the orbit, and six are contained within it.

The Muscles belonging to the Eyebrows are two.

*M. Occipito-frontalis* (fig. I. k.) is a broad thin Muscle originating from the upper edge of the great transverse occipital ridge, and coalescing with its fellow at the occipital tubercle; it ascends as a thin Muscle about an inch and a half from this ridge, then becomes tendinous, expands over the whole surface of the head in a tendinous form, being closely connected with the bed of the hair, and loosely with the subjacent pericranium; upon the forehead it again becomes fleshy, and is lost by insertion into the eyebrow. *Use.*—It raises the Eyebrows, as observed in the expression of surprise, and it also draws forward or backward the scalp, as its front or back muscular attachment acts.

*M. Corrugator Supercilii* (fig. I. l.) is covered by the next Muscle: it originates from the inner angular process of the frontal bone, passes upwards and outwards, and is inserted into the inner end of the cellular tissue supporting the Eyebrow. *Use.*—It antagonizes the last Muscle, drawing the Eyebrow down, or knitting the Eyebrow, as it is commonly called, either in frowning or in deep thought.

The Muscles of the Eyelids are two, one external to the orbit, the

*M. Orbicularis Palpebrarum* (fig. I. m.), which is a thin expanded circular Muscle spread upon and above the upper, and upon and below the lower eyelid, and closely connected at the inner corner of the orbit with the ligament by which the cartilages of the eyelids are connected with the nasal process of the upper jawbone. *Use.*—It closes the Eyelids.

The lower Eyelid, from its own weight, drops when the *M. Orbicularis* is inactive, and therefore requires no Muscle; but to keep the upper Eyelid raised it requires a Muscle, which is situated in the orbit, together with the Muscles of the globe.

*M. Levator Palpebræ Superioris* (Anat. Pl. XI., fig. IV. b.) arises tendinous from the upper edge of the optic hole, becomes muscular as it expands, and elongated forwards, and is inserted by a broad delicate tendon into the cartilage of the Upper Eyelid.

The Muscles of the Globe of the Eye consist of six, four straight and two oblique; the

*M. Recti Oculi* (fig. IV. e. d. e. f.) all originate tendinous from the optic hole, and are called, from their use, the upper *Levator* (e.), the under *Depressor* (e.), the inner *Adductor* (f.), and the outer *Abductor Oculi* (d.); each forms a long narrow fleshy belly, which terminates in a tendon to be inserted into the sclerotic coat of the Eye where the conjunctive coat is reflected from the globe on to the eyelids; the tendons then spread out upon the globe of the eye, and, expanding beneath the just named tunic, form the so-called White of the Eye, being inserted as far as that transparent cornea.

The *Use* of the several Muscles is implied in their names.

*M. Obliquus Superior Oculi* arises from the optic hole between the tendinous origins of the *M. Levator* and *Adductor*; it soon becomes fleshy, runs along the upper edge of the latter Muscle, and, as it approaches the inner corner of the orbit, terminates in a tendinous cord which runs over a little ligamentous loop attached to the inner angular process of the frontal bone, then descends and is inserted into the under part of the globe about its middle. *Use.*—It turns the front of the globe upwards and inwards, as in the expression of hope.

*M. Obliquus Inferior Oculi* (fig. IV. g.) is a short Muscle originating from the orbitar process of the upper jaw-bone near its junction with the lachrymal; it runs outwards fleshy, and is inserted tendinous into the middle of the outside of the globe. *Use.*—It turns the front of the globe outwards and downwards, and gives expression to suspicion.

If both the Oblique Muscles act together, the globe obeys neither, but a third motion is produced which causes squinting.

Fourthly. The Muscles of each Auricle are divided into those which move it upon the Skull, and those which move its cartilaginous pieces upon each other; the former consist of three or four, the latter of five. It is necessary, however, here to mention very cursorily the parts of which the Auricle is composed. It is divided into the *lobe* or lower part, which consists only of a doubling of the skin containing fat, and is the part pierced for ear-rings; and the *pinna* or *gristly part*, which is composed of cartilage covered with skin; the latter is divided into elevations and depressions: the marginal elevation is called *helix*, a little in front of which is the *antihelix*, the two being separated by the *fossa innominata*, or unnamed pit; and in front of the antihelix is a large cavity called, from the resemblance to the open mouth of a horn, *concha*, which leads down to the external auditory passage; in front of the concha, like a little valve, which, in some animals, it really is, is the *tragus*; and opposite it and behind, at the termination of the antihelix, is a little elevation called the *antitragus*.

*M. Attollens Auriculæ* (Pl. X., fig. I. n.; Pl. XI., figs. XXVI. & XXVII. a.) is a thin fan-shaped Muscle on the side of the temple, from the cellular tissue of which it arises; its fibres collect, descend, and are inserted at the back of the fossa scaphoides. *Use.*—It raises the auricle, and has no antagonist, the weight of the auricle restoring it to its original place when this Muscle ceases to act.

*M. Attrahens Auriculæ* (figs. XXVI. & XXVII. b.) is a short small Muscle arising from the root of the zygomatic process of the temporal bone, and is inserted into the root of the front of the helix.

*M. Retrahentes Auriculæ* (Pl. X., figs. I. o.; Pl. XI., figs. XXVI. and XXVII. c. c.).—Sometimes two, but often only one short and delicate Muscle, originating from the root of the mastoid process, and inserted into the back of the conch. The *Uses* of the last two Muscles are implied in their name, and they are antagonists.

Four of the five Muscles of the Auricular Cartilages are placed on their external surface, and tend to vary the depth of the auricular cavity by drawing the cartilages together: they are called—

*M. Helicis Major* (fig. XXVI. d.)
*M. Helicis Minor* (ib. e.)
*M. Tragicus* (ib. f.)
*M. Antitragicus* (ib. g.)

These are all antagonized by a single muscle,

*M. Transversus Auris* (fig. XXVII. d.), situated on

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the back of the concha and antihelix, which renders the auricular cavity shallow.

c.—Of the Muscles of the Lower Jaw.

The proper Muscles of the Lower Jaw, or Masticating Muscles, consist only of seven pairs, four of which elevate and rotate it, and the other three depress it.

*M. Temporalis* (fig. II. p.) is the largest and most powerful; it arises fleshy from the whole temporal pit, and from the inside of a strong fascia which is attached to the temporal ridge of the frontal, parietal, and temporal bones above, and the zygomatic arch below; it is inserted tendinous and fleshy around the whole coronoid process of the lower jaw. *Use.*—It elevates the jaw very powerfully, and draws it backwards.

*M. Masseter* (fig. I. q.) originates from the under part of the zygomatic process or prominence of the cheek, consists of bundles of fleshy fibres intermingled with tendon, and is inserted tendinous and fleshy upon the outside of the angle of the lower jaw. *Use.*—It elevates the lower jaw, and draws it forwards.

Within the arch of the lower jaw and behind, are found the other two pairs.

*M. Pterygoideus Internus* (fig. III. r.), which arises from the pterygoid pit of the sphenoid bone fleshy, passes downwards and backwards, and is inserted on the inside of the angle of the jaw, corresponding to the insertion of *M. Temporalis*. *Use.*—Similar to the last Muscle.

*M. Pterygoideus Externus* (fig. III. s.) is a short, thick, bulky, horizontal Muscle, arising from the whole outer surface of the moscular plate of the pterygoid process of the sphenoid bone; it passes a little backwards, and is inserted into the inside of the neck of the lower jaw. *Use.*—The Internal Pterygoid Muscles act for the most part singly, and alternately bring forward one or other side of the jaw, thus rubbing or grinding the teeth together, and principally perform the office of breaking up the food between the grinding teeth.

The Muscles which depress the Lower Jaw are all connected with the hyoideal or tongue bone, and this being movable, or rather suspended by ligament and muscles between the styloid processes of the temporal bones and the top of the air-tube, it will be necessary, before describing them, to give a short account of the Larynx, as the crowning and most important part of the Air-tube is called.

The Larynx is placed at the top of the Windpipe, *trachea*, and consists of five cartilages, the largest of which, occupying the front, and resembling in its form the half-opened boards of a book, is called the *Thyroid cartilage*, from its shielding the smaller cartilages and other important parts; its two sides, called *wings*, join in front, forming the projection remarkable in the male, and known as *Adam's apple*; behind, each wing terminates in an *ascending horn*, connected by a round ligament to each horn of the tongue-bone, and below by a shorter and *descending horn*, which is united by a ligamentous capsule on each side to the Cricoid cartilage; an expanded ligament connects the lower edge of the wings also with the same cartilage, and by another broad ligament their upper edge is attached to the lower margin of the tongue-bone. The *Cricoid Cartilage*, named from its resemblance to a ring, is placed below the last, and attached by its lower edge to the top of the Windpipe; it is narrow in front, where joined to the Thyroid, but deepened considerably behind, and has attached, by capsular ligaments to its top, a pair of triangular cartilages called the *Arytænoid*. From the base of these to the back of the junction of the wings of the Thyroid Cartilage, a pair of ligaments, called the *Vocal chords*, are stretched, and the aperture between these is called the *Chink of the Glottis*. As the food in passing from the mouth into the gullet, which is placed behind the Larynx, must necessarily pass over this chink, it requires a covering to prevent the food getting into the Larynx, which, however, a small quantity sometimes does, and is then, in common language, said to have gone the wrong way, and causes suffocation; this covering is furnished by the fifth cartilage, called the *Epiglottis*, which covers it like a trap-door, but with this difference, that whilst in a trap the door drops down into or upon its frame, in this case the frame or chink of the glottis is raised up to it, and the epiglottis, which is naturally upright, then falls upon it, and forms a shoot from the back of the tongue over which the food readily glides without the possibility of getting into the Larynx.



The Tongue-bone is prevented ascending directly by three pairs of Muscles which are inserted into it, and indirectly by two pairs which are attached to the Laryngeal cartilages; hence it affords a fixed attachment for the Muscles depressing the Lower Jaw.

*M. Sterno-hyoideus* (figs. IV. and V. a. a.).—A long narrow Muscle arises by a thin tendon from the back of the first piece of the breast-bone, from the sterno-clavicular articulation, and from the inner end of the collar-bone; it is inserted into the lower edge of the base of the tongue-bone.

*M. Omo-hyoideus* (fig. IV. b.) is a long two-bellied Muscle, commencing from the ligament of the upper notch of the blade-bone, from which it ascends fleshy to the hind edge of the *M. Sterno-mastoideus*, becomes tendinous, and passing on its inner side, emerges from its front edge, again becomes muscular, and ascends nearly vertically to be inserted into the base of the tongue-bone externally to the preceding Muscle.

*M. Thyro-hyoideus* (fig. IV. c.) is covered by the *M. Sterno-thyroideus*, which, being turned off, exhibits its origin from the upper edge of a transverse ridge upon the outer surface of the wing of the thyroid cartilage; it is inserted into the base of the tongue-bone.

*M. Sterno-thyroideus* (fig. IV. d.) arises from the back of the first piece of the breast-bone and from the cartilage of the first rib; it ascends upon the side of the windpipe, to be inserted into the tranverse ridge of the thyroid cartilage below the origin of the last Muscle.

*M. Crico-thyroideus* (fig. VI. c.) is a little triangular Muscle, with its tip or origin below, from the front of the cricoid cartilage; it runs upwards and backwards to be inserted into the lower edge and root of the lower horn of the thyroid cartilage.

All these five Muscles, if the depressors of the jaw were inactive, would pull down the tongue-bone and the whole Larynx and Windpipe towards the chest; and even when these Muscles do act, they assist them by pulling down the tongue-bone and Larynx still further. But they are now to be considered as preserving the fixed position of the tongue-bone against the operation of the depressing Muscles of the Jaw, which, when so acting, strive to pull the tongue-bone and Larynx upwards.

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*M. Digastricus* (fig. IV. f. f.) is, as its name implies, double-bellied; it arises fleshy from the digastric pit of the temporal bones, passes downwards and forwards towards the appendage of the tongue-bone, to which a ligamentous loop is attached, and through it the middle tendon of this Muscle plays; it then again becomes fleshy, ascends to the base of the chin, and here is inserted tendinous and fleshy.

*M. Mylo-hyoideus* (figs. IV. & IX. g.) is a broad, expanded Muscle, covered before by the anterior belly of the last Muscle; it arises from the upper edge of the base of the tongue-bone, joins its fellow in front, and, ascending, is inserted fleshy into the inside of the lower jaw, from the back of the chin to opposite the root of the last molar tooth.

*M. Genio-hyoideus* (fig. IV. h.) is a straight Muscle, not seen till the junction of the last pair of Muscles has been divided; it arises from the base of the tongue-bone, and, becoming tendinous, is inserted into the little spine at the back of the chin.

The three Muscles just described, when the jaw is kept closed by its elevating Muscles, pull up the tongue-bone, and with it thrust up the Tongue against the bony palate, in which they are also assisted by another pair of Muscles, the

*M. Stylo-hyoideus* (fig. VII. i.), placed before the hind belly of the *M. Digastricus*, and arising from the lower half of the styloid process of the temporal bone; it is inserted into the tongue-bone at the junction of its horn with its base.

In connexion also with the tongue-bone and styloid process of the temporal bone, are

THE MUSCLES OF THE TONGUE:

These consist of three pairs, and a fourth, which is attached only to the Tongue, and indeed forms the principal part of its structure, and moves it upon itself.

*M. Hyo-glossus* (fig. VII. k.) arises from the upper edge of the tongue-bone, and is inserted into the under and middle part of the tongue. *Use.*—It depresses the middle of the Tongue, and renders it spoon-shaped.

*M. Genio-hyo-glossus* (fig. VII. l.) is a fan-shaped Muscle, arising from the little stud at the back of the chin, is attached below to the base of the tongue-bone, and is inserted into the under part of the Tongue behind its anterior third. *Use.*—Its actions are very numerous: if the whole Muscle acts, it draws down and renders the middle of the Tongue concave; if the front and back fibres act simultaneously, they help to render the Tongue convex from before to behind; by the action of its posterior fibres the Tongue is projected from the mouth, and the anterior fibres being rendered tense, are then capable of drawing the tongue back again; the part connected with the tongue-bone depresses the jaw if that bone be fixed, or elevates it if the jaws are kept close.

*M. Stylo-glossus* (fig. VII. m.) arises from the styloid process above the *M. Stylo-hyoideus*, is a slender fleshy Muscle, runs along the under part of the Tongue from its base, and is inserted into its tip. *Use.*—It assists the former Muscle in drawing the Tongue back into the mouth, and the *M. Hyo-glossus* in rendering it spoon-shaped, by raising its base.

*M. Lingualis* (fig. VII. j.).—This is the proper Muscle of the Tongue, and passes longitudinally from its base to its tip, between the *M. Hyo-glossus* and *Genio-hyo-glossus*. *Use.*—By the contraction of the pair, the sides of the Tongue are shortened, and it is rendered convex laterally.





The cavity of the Mouth is separated from the pharynx, or top of the gullet, by means of a pendulous curtain, *velum palati*, from the hind edge of the bony palate, consisting of a doubling of the delicate skin lining the mouth and gullet, in which are included certain Muscles. This curtain is attached to the Tongue in front by one pair of pillars, as they are called, and to the sides of the gullet by another pair, and each of these contain a pair of Muscles; the curtain itself is moved by two pairs of Muscles; and the little body called the *uvula*, pendulous from the middle of the curtain, has also its single Muscle.

*M. Palato-glossus* is placed in the anterior pillar, arises from the side of the base of the Tongue, and is inserted into the soft palate.

*M. Palato-pharyngeus*, situated in the posterior pillar, arises from the side of the gullet, and is inserted into the soft palate, where it blends with the last Muscle. *Use.*—Both these Muscles approximate the base of the Tongue and soft palate, and cut off the communication between the mouth and pharynx; which action is completed by

*M. Tensor Palati* (fig. VIII. o.).—This small Muscle arises tendinous and fleshy from the spinous process of the sphenoid, and from the under part of the whole Eustachian tube; as it descends it becomes tendinous, plays around the hamular process of the sphenoid bone, and ascending as a thin expanded tendon is inserted into the soft palate.

Its antagonist is a Muscle close to and behind it, but the tendon of which does not accompany it, viz.,

*M. Levator Palati* (fig. VIII. p.).—It arises from the under part of the petrous portion of the temporal bone, and from the Eustachian tube, and it is inserted into the soft palate. *Use.*—It elevates the soft palate, bringing it upon the same plane as the bony palate, and cuts off the communication between the pharynx and nostrils.

*M. Azygos Uvulæ* (fig. VIII. q.) is a single Muscle arising from the hind point of the palatine crest; it descends into the Uvula, where it terminates. *Use.*—This is probably to assist the intonation of the voice by increasing the aperture of the arch of the *fauces* or swallow.

Behind the soft palate, and descending from the under part of the basilar process of the occipital bone, from the pterygoid processes of the sphenoid bone, and from the back of both jaws, is a large muscular funnel called the Pharynx or gullet, which consists of five pairs of Muscles: two of these expand and raise it to receive the food as it is thrown backwards from the mouth, and the other three alternately compress and squeeze it down into the œsophagus; of the expanding and elevating Muscles, one pair, the *M. Palato-pharyngei*, have been already described; the other is *M. Stylo-pharyngeus* (fig. VII. r.) which arises fleshy from the styloid process of the temporal bone, and is inserted into the side of the pharynx.

The compressing Muscles are the

*M. Constrictor, Superior, Medius*, and *Inferior Pharyngis* (fig. IX. s. t. u.). The *first* of these arises from the occipital, sphenoid, upper and lower jaw-bones; the *second* from the occipital bone, and from a seam which runs between the two Muscles forming this pair; and the *third* from a continuation of the same seam.



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The first of the three is inserted into the middle of the back of the pharynx in a white seam, and the two latter into the sides of the thyroid and cricoid cartilages. *Use.*—The first of the three is, strictly speaking, only an elevator of the pharynx; the other two, however, both elevate and narrow its diameter.

### Muscles of the Larynx.

The Muscles of this organ may be divided into those which change its position in the Neck, and consequently lengthen or shorten the air-tube, and those which move its several pieces in such manner as to operate upon its chink and upon the vocal chords. Of the former kind are all the Muscles which elevate or depress the tongue-bone; but of the latter, only one pair, the *M. Crico-thyroidei*, have been yet described; besides which, there are four pairs and a single Muscle, which move the Arytænoid upon the Cricoid cartilage, and two pairs which approximate the Epiglottis and the Laryngeal chink.

*M. Crico-Arytænoideus Posticus* (fig. x. a.) arises fleshy from the hind broad part of the Cricoid cartilage, and is inserted into the base of the Arytænoid.

*M. Crico-Arytænoideus Lateralis* (fig. xi. b.) is smaller, arises from the side of the Cricoid, and covered by the wing of the Thyroid cartilage; it is inserted into the side of the base of the Arytænoid. *Use.*—Both these Muscles open the chink of the Larynx, the former from before to behind, at the same time tightening the vocal chords, and the latter from side to side by pulling them apart.

The antagonist of the first of the Muscles is

*M. Thyro-Arytænoideus* (fig. xi. c.), which, arising from the inside of the wing of the Thyroid, is inserted above the last into the Arytænoid cartilage.

The antagonist of the second is

*M. Arytænoideus Obliquus* (figs. x. & xi. d.), which, arising from the back of the base of one Arytænoid, is inserted into the tip of the other Arytænoid cartilage; the two Muscles of this pair therefore decussate like a St. Andrew's cross. *Use.*—Both diminish the aperture of the Larynx, and render the vocal chords loose.

*M. Arytænoideus Transversus* is a single Muscle running from the inner edge of one to that of the other Arytænoid cartilage. *Use.*—It approximates the cartilages, and helps to close the chink.

The Muscles operating on the Epiglottis especially are two, very thin and delicate, and discernible only in very muscular subjects; they are called

*M. Arytæno-Epiglottideus* and

*M. Thyro-Epiglottideus*;

The former arising from the Arytænoid, and the latter from the Thyroid cartilage, and both are inserted into the side of the Epiglottis. *Use.*—It is probable that their use is only to adjust nicely the Epiglottis upon the top of the Larynx, as the Arytænoid cartilages and vocal chords, with the intervening chink, are actually raised to the Epiglottis by those Muscles which raise the tongue-bone.

### Of the Muscles of Respiration.

These consist of two kinds; those which operate directly upon the Chest, and those which act indirectly upon it by the reversion of their actions; such are all the Muscles connecting the Upper Extremities with the Chest, and already described, viz., *M. Pectoralis Major* and *Minor*, and *Serratus Magnus*; also those which bow the body forwards upon the pelvis, the *M. Rectus, Externus* and *Internus Abdominis*, and the pair which steady it, *M. Quadratus Lumborum*, all of which are called into action only in difficult respiration. But the former kind may also be subdivided into three sets,—supporters of the Chest, elevators, and depressors of the Ribs.



1. The *supporting Muscles* of the Chest consist of four pairs: one of them has been already described as acting specially upon the head, the *M. Sterno-cleido-mastoideus*, but from its attachment to the upper piece of the breast-bone it assists in holding up and fixing the top of the chest, rendering it the point upon which the other ribs are moved. The proper suspending Muscles are, however, the

*M. Scalenus Anticus, Medius*, and *Posticus* (Pl. X., fig. iv. l. m. n.)—The first of these arises from the fourth, fifth, and sixth; the second from the whole seven; and the third from the fifth and sixth cervical transverse processes, by as many tendons, which are connected with each other; they descend muscular, and are inserted tendinous, the first two into the upper edge of the first rib and at a little distance apart, and the third into the upper edge of the second rib near the spine. *Use.*—In general they are mere suspendors, but in very difficult respiration forcibly raise the top of the chest. As the weight of the chest is constantly hanging on them, they assist materially in preserving the erect position of the neck; but if the Muscles on either side act alone, they draw the neck forwards and downwards to that side.

2. The *Elevating Muscles* of the Ribs consist of twenty-six pairs, of which there are twenty-four pairs of

*M. Intercostales*, which run from the edge of one to that of another rib; these, according to their situation upon the outer or inner plane of the chest, are called *Intercostales Externi* and *Intercostales Interni*; the *former* of these arise from the whole under edge of the upper eleven ribs, and their short fibres pass downwards and forwards to the upper edge of the rib below, as far as the cartilage; whilst the *latter* commence close to the breast-bone from the under edge of the cartilage, and from the under edge of each of the upper eleven ribs, continuing as far back as their angles; their fibres pass backwards and downwards to be inserted into the edge of the rib below, and in so doing cross the external layer. *Use.*—By the contraction of both sets of Muscles the space between the ribs is diminished, and the cavity of the chest consequently shortened, but expanded laterally in proportion.

*M. Levatores Costarum* are usually described as separate Muscles, but are really only the beginning of the origins of the External Intercostal Muscles, from the transverse processes of the dorsal vertebres, by tendinous slips. Their insertion is similar to that of the External Intercostal Muscles.

*M. Serratus Posticus Superior* is a broad fleshy Muscle, covered by the blade-bone and its Muscles, arising by a thin tendon from the lower three cervical and the upper two dorsal spines, and is inserted by finger-like slips into the outside of the four ribs following the first. *Use.*—To elevate the ribs.

The *Diaphragm* or *Midriff* separates the belly from the chest, and forms a movable floor upon which the

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heart principally rests, capable of elevation when expiration is performed, and of descent on inspiration. It is commonly divided into two portions: the superior or greater portion arises by fleshy slips from the back of the ensiform cartilage, and from the inside of the lower six pairs of ribs near their cartilages, also by four tendinous slips, which, soon becoming muscular, coalesce to form the legs or inferior and lesser portion; all the fibres ascend upwards and inwards towards a middle heart-shaped tendon, into which they are inserted. The legs, in their ascent, are separated by a space close to the spine, through which the aorta passes, and then interweaving with each other form a second hole in the muscular expansion on the left side, through which the gullet passes, whilst a hole in the tendon transmit the *Vena Cava Inferior* from the belly and the chest. *Use.*—When the diaphragm contracts, its middle tendon is drawn down, and the vaulted form which the muscle possesses when at rest becomes converted nearly into a flat plane, and consequently the capacity of the chest is increased vertically; whilst the diminution of its lateral extent, which might be supposed likely to occur from the considerable origin of this Muscle from the ribs, is prevented by the intercostal and inferior scalene Muscles.

3. The *Depressing Muscles* are

*M. Serratus Posticus Inferior* (Pl. VII., XXIV.), which arises by a broad thin tendon from the last two dorsal and the upper three lumbar spines; it is inserted by finger-like slips into the outer and back part of the lower four ribs. *Use.*—To antagonize the last and to depress the ribs.

*M. Depressores Costarum* arise from the upper edge of one, and inserted into the lower edge of the rib but one above it, upon the inner plane of the chest. *Use.*—Implied in its name.

*M. Sterno-costalis* is placed on the back of the breastbone, from the ensiform cartilage and second piece of which it arises, passes shortly upwards and outwards, and is inserted into the cartilages of the third and two following ribs. *Use.*—It restores the position of the cartilages by bringing them down after eversion during inspiration.

### Of the Muscles of the Trunk.

The Spine, although capable of preserving its own virtually erect posture without other aid than the ligaments and elastic substances by which its pieces are connected together, is yet unable to support it by these means alone when the large cavities of the Chest and Belly appended in front of it are continually by their weight tending to bend it forwards. In order, therefore, to preserve the Trunk erect, and to steady the Spine so as to render it the fixed point upon which the motions of the Chest and Head, and indeed also of the Upper Limbs, are performed, as well also for the performance of those motions between the several pieces of the Spine which are necessary for preserving the equilibrium of the body in the varied and varying motions which are performed both by body and limbs, a great number of Muscles are placed upon the back of the Vertebral Column in order to counteract the disposition to bend forwards constantly operating upon it by the weight of the Chest and Belly. How great this disposition is, a comparison of the number of Muscles situated on the back, and erecting or extending the Spine with those placed in front which bend it forwards, will immediately indicate. All these Muscles are in pairs, and the two Muscles of a pair perform either extension or flexion of the Spine and Trunk according to their position; but if only one Muscle of the pair act, it sways the body to its own side forwards or backwards, as may be. It is also further to be observed, that the erect position of the Trunk now adverted to is only with reference to the pelvis; its support in that position upon the Thigh-bones will be considered hereafter in describing the Muscles passing from the Trunk to the Lower Limbs.



The three pairs of Muscles which specially preserve the erect position of the loins and back upon the pelvis are commonly called the Sacro-lumbar Mass, and consist of the following:—

*M. Sacro-lumbalis* (Pl. VII., XXVII.) is the outermost of this mass, and springs from the back and spines of the rump-bone, from the posterior spines of the hip-bone, and from the transverse and spinous processes and vertebral arches of all the vertebres of the loins in common with the next Muscles, and also by six or eight fleshy slips usually called *Musculi ad Sacro-lumbalem Accessorii*, from as many of the lower ribs; it ascends upon the back of the chest, and is inserted by long thin tendons into the angles of all the ribs. *Use.*—Besides the general action already described, it pulls down the ribs, and is, therefore, a Muscle of expiration.

*M. Longissimus Dorsi* (Pl. VII., XXVI.), situated on the inner side of the preceding, and having the same origin; it is more bulky, and is inserted into all the dorsal transverse processes by small double tendons, and by tendinous and fleshy slips into the upper ten ribs near their tubercles. *Use.*—Similar to the last mentioned.

*M. Spinalis Dorsi* (Pl. VII., XXV.) is the third and smaller Muscle of the Sacro-Lumbar Mass, and situated close upon the ridge of the Spine, arising from the Spinous processes of the upper two lumbar and lower three dorsal Vertebres by as many tendons; it is largely composed of tendinous cords, and is inserted by tendons into the spinous processes of the uppermost nine dorsal Vertebres below the first.

The remaining Muscles connected with the Spine are attached to one or other or all its different regions.

The two following sets are extensors if they act in pairs, or incline the Spine to that side, if acting singly.

*M. Multifidus Spinæ*, which lies in the groove between the transverse and spinous processes, arises from the back of the rump-bone, from the posterior spines of the hip-bone, from the transverse processes and arches of all the vertebres, to the fourth cervical inclusive, by as many tendons, which soon become muscular, and ascending obliquely upwards are inserted by tendinous slips into the spinous processes of all the Vertebres, except the first of the Neck.

*M. Interspinales* are little Muscles placed between the points of the spinous processes of all the vertebres except the first and second cervical; they are most distinct in the Neck.

All the other Muscles, if they act in pairs, are extensors, and at the same time prevent the lateral swaying of the Spine by bracing it up like the shrouds of a ship's mast, but if they act only on one side, they incline the Spine above their origin to their own side.

*M. Quadratus Lumborum* (Pl. VIII., fig. 1.), of



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a square shape, as its name implies, arises from the posterior spines of the hip-bone, and from the hind part of its crest, and is inserted into the transverse processes of all the lumbar vertebres, by a short tendon into the body of the last dorsal vertebre, and into the lower edge of the last ribs. *Use.*—Besides its action upon the Spine, it draws down the ribs, and is therefore a Muscle of expiration.

*M. Semi-spinalis Dorsi* arises from the transverse process of the tenth and three superjacent dorsal vertebres, tendinous and fleshy, and is inserted into the spinous processes of the upper four dorsal and lower two cervical vertebres.

*M. Semi-spinalis Colli* originates tendinous from the upper six dorsal transverse processes, becomes fleshy, and again tendinous as it is inserted into all the cervical spines except the first and last.

Along the outer margins of the Cervical Spine a pair of Muscles are placed analogous to the *M. Quadratus* of the loins, viz.—

*M. Transversalis Colli*, which originates from the upper five dorsal transverse processes, and is inserted into all those of the Neck excepting the last and first. *Use.*—If both Muscles operate they act like shrouds; but if only one, it draws the Neck towards that side.

Its junction is also assisted by the

*M. Inter-transversales*, which pass from the upper edge of one to the lower edge of another transverse process throughout the whole length of the Spine, except between the second and first of the Neck.

The Muscles which bend the Spine itself forwards are generally but two, and sometimes three pairs; but of these, one pair, the *M Psoæ Magni*, are strictly Muscles of the Lower Limbs, and the other two only proper flexors of the Spine. Of these the lower pair are

*M. Psoæ Parvi* (Pl. VIII., fig. 1.), which are often wanting; they arise tendinous from the sides of the brim of the pelvis, ascend on the inner and fore part of the Great Psoas, and are inserted into the sides of the bodies of the upper two lumbar and sometimes of the last dorsal vertebre. *Use.*—They bend the loins upon the pelvis.

*M. Longus Colli*, upon the Neck, arises from the sides of the bodies of the upper three dorsal, and from the transverse processes of the sixth to the third cervical vertebres inclusive, and is inserted by tendinous and fleshy slips into the fronts of the bodies of all the cervical vertebres. *Use.*—It bends the Neck forwards on the Spine.

Flexion of the Spine is, however, more extensively, though less directly, performed by the three largest of the five pairs of Muscles forming the walls of the belly, which are attached to the Chest and not upon the Spine through it. Of these, the most efficient is,

*M. Rectus Abdominis* (Pl. VI., w.), which extends from the pelvis to the chest along the front of the belly, enclosed in a tendinous sheath to be presently noticed; it arises by a strong flat tendon to the inner side of the spine of the share-bone, soon assumes a broad flattened muscular form, ascends, and is inserted into the cartilages of the fifth, sixth, and seventh ribs. Its length is divided by two or three and a half tendinous intersections, rendering it a three or four-bellied Muscle. *Use.*—It draws down the front of the chest, and is, therefore, a Muscle of expiration, and, continuing its action, bends the Spine forwards upon the pelvis. It also compresses the bowels, and its tendinous intersections are generally said to be for the purpose of enabling portions of it to act separately; it would seem, however, more probable that the purport of this division is to render the Muscle more powerful and less liable to rupture. The sides of the belly are formed of three pairs of Muscles, two of which, besides acting as compressors of the abdominal contents, draw down the ribs, and are, therefore, both Muscles of expiration and flexors of the Spine, but the third pair compresses the bowels alone.



*M. Obliquus Externus Descendens Abdominis* (Pl. VI., v.) arises by as many finger-like heads from the eight lower ribs which run between the similar heads of the *M. Serratus Magnus*; in front it intermingles with the *M. Pectoralis Major*, and behind is overlapped by the *M. Latissimus Dorsi*; it passes downwards and forwards as a broad expanded Muscle, which is inserted below fleshy into the outer lip of the hip-bone; and from the superior anterior spine of the hip-bone up to the cartilage of the seventh rib it sends out a broad tendon, which, passing in front of the last described Muscle, joins its fellow between that pair from the ensiform cartilage to the junction of the share-bones, forming a middle line called the white line, *linea alba*, and the part attached to the spine of the hip-bone, and becoming tendinous passes across the femoral vessels connected with the broad sheath of the thigh, and with it forming the *crural arch* as it proceeds to be fixed in the spine of the share-bone, and turning outwards runs a short distance on the body of that bone to form a triangular attachment commonly called *Gimbernat's Ligament.*

In the broad expanse of tendon from this pair of Muscles covering the front of the belly, it is usual to speak of certain lines, 1st. The Semi-lunar Lines (*lineæ semi-lunares*), which mark the termination of the fleshy parts of these Muscles, the concavities of which face inwards towards each other; 2nd. The White Line (*linea alba*), formed by the junction of the two tendons in the middle of the body between the *M. Recti Abdominis*; 3rd. The Transverse Lines (*lineæ transversales*), which are connected with the tendinous intersections of those Muscles.

Three large and important apertures are also found in this conjoined tendon in the middle of the white line, the Navel or Umbilical aperture (*umbilicus*), through which the placental vessels of the mother have passed into the belly of the fœtus; and the two external abdominal rings, lengthened triangular apertures, above and to the inner side of each pubic spine, and formed by the attachment of one portion of the external oblique tendon to the spine and another to the symphysis pubis, which portions are called the outer and inner columns of the ring, through which the Spermatic vessels pass from and to the belly and testes.

*M. Obliquus Internus Ascendens Abdominis*, within the last Muscle, arises fleshy from the upper outer half of the crural arch, and from the whole lip of the hip, tendinous also from the tendinous origin of the

*M. Latissimus Dorsi*, its fleshy fibres spread out like a fan; the posterior are inserted fleshy into the cartilages of the lower six ribs, and into the ensiform cartilage, whilst the anterior fibres terminate in a tendon at the semi-lunar line, and then splitting into two layers include the *M. Rectus*, and terminate in the white line, the front layer being closely connected with the tendon of the External Oblique and the back layer with

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that of the Transverse Muscle. *Use.*—This and the last pair of Muscles, although their fibres run in contrary directions, have the same action upon the chest, viz., pull it down, and are, therefore, Muscles of expiration, and, continuing their effort, bend the Spine with it. One of each pair of Muscles acting on the same side inclines the Chest and Spine in that direction.

*M. Transversalis Abdominis* placed within the last Muscles, arises fleshy from the insides of the lower seven ribs, by a broad tendon from the last dorsal and the upper four lumbar transverse processes, and fleshy from the upper outer half of the crural ring; its fleshy fibres pass forwards from behind to before, and at the semi-lunar line send out a tendon which, passing behind the posterior layer of the Internal Oblique tendon, is inserted with it.

The last pair of Abdominal Muscles, which are often wanting, are merely compressors of the bladder.

*M. Pyramidalis* (Pl. VI., x.), which arises from the share-bone near its junction with its fellow, rises upwards, narrowing as it ascends, and is inserted into the white line midway between the pubes and navel.

### Of the Muscles of the Lower Limbs.

The Muscles of the Lower Limbs consist of sixty-one pairs, of which twelve arise from or cover parts of the Basin, and operate upon the Thigh; seven arise from or run along the Thigh, and act upon the Leg; ten arise from the Leg, and are attached to the Foot or Toes; and nineteen from the Foot, which are connected either with the Tarsal, Metatarsal, or Toe-bones.

All the Muscles of the Lower Limbs are included in tendinous sheaths or *fasciæ*, as they are called anatomically. Of these, the principal are the *Fascia lata*, or Broad Sheath of the Thigh, the Anterior Tibial Sheath, and the Plantar Sheath.

The tendinous insertion of the external layer of the Abdominal Muscles stretches from the superior anterior spinous process of the hip-bone to the spine and symphysis of the share-bones; and, unconnected with the Basin except at those points, leaves a considerable space between it and the body of the share-bones through which some muscles, vessels, and nerves pass into the thigh, over which it expands like a flat bridge, and hence bears the name of the *Crural Arch*, a part of great importance in reference to Surgical Anatomy. From this Crural Arch commences

The *Broad Sheath.*—It originates by a very sharp point a little to the outside of the spine of the share-bone, becomes wider as it passes outwards, and expanding over the whole thigh down to the knee, upon which it is lost, it dips in among the Muscles at the back of the thigh, and is attached to the linea aspera. But that already mentioned is not the whole of its attachment; for after having reached nearly the middle of the front of the hip-joint, it turns suddenly inwards and upwards, forming an edge like a sickle, which for that reason is called the *falciform process*; and then ascending, is fixed to the sharp edge of the body of the pubic bone above the thyroid hole, and continuing its attachment inwards, runs along the edge of the branches of the share and haunch bones down to the tuberosity of the latter, where it becomes confounded with the Great Gluteal Muscle. In this way a large aperture, the *Crural Ring*, is formed in front and to the inner side of the hip-joint, of which the outer anterior part is formed by that portion of the sheath connected with the Crural Arch, and the inner posterior by that attached to the body of the share-bone. Processes are sent towards the linea aspera from the inside of the Sheath, which divide its interior into three distinct cavities, as is proved by the pus contained in fascial abscess of the thigh not being generally diffused amongst all the Muscles covering it, but only in one or other cavity as may be. One of these cavities includes all the extensor Muscles of the leg on the front of the thigh; a second envelopes those on the inner side, which adduct the thigh; and the third behind surrounds the flexor Muscles of the leg. The use of this Sheath is to keep the Muscles together, and whilst it renders the form of the limb more comely, by preventing them dangling loosely when unemployed, it also strengthens them, and increases their power in action by bringing their fibres more closely together, a physiological fact which is well known to common people, who, when preparing themselves for muscular effort, tightly bandage the limb more particularly to be called into action, as they justly say, to increase its strength. For this purpose, also, the Sheath is furnished with a proper Muscle, the

*M. Tensor Vaginæ Femoris* (Pl. VI., r; Pl. VIII., fig. 1.*), which, arising fleshy and tendinous from the superior anterior spinous process of the hip-bone, passes backwards and downwards, to be inserted into the sheath a little below the great trochanter of the thigh-bone. *Use.*—Besides tightening the Sheath it rotates the thigh inwards, and it is remarkable as being one of the only two Muscles by which that motion is performed.

The Muscle which bends the thigh upon the trunk, and is, therefore, the first agent in progression by raising the leg from the ground, is commonly described as two, the *M. Psoas Magnus* and the *M. Iliacus Internus.* It would be far better, however, to consider it, as it is in fact, a bicipital or two-headed Muscle, and call it the

*M. Vertebro-Iliacus* (Fig. 1. a. a.).—Its *long head* arises from the side of the bodies, and from the transverse processes of the last dorsal, and of all the lumbar vertebres; and these several slips uniting together form a large belly, which descends along the brim of the pelvis, and becomes tendinous as it passes behind the Crural Arch. Its *short head* originates from the whole belly of the hip-bone, and its fibres running inwards and downwards unite with the tendon of the long head, and pass with it behind the Crural Arch, obliquely across the fore and outer part of the capsule of the hip-joint, to be inserted into the inner and back part of the less trochanter, enveloping in its course the whole of that process. *Use.*—Besides flexing the thigh on the trunk it twists it outwards; but if its action be reversed by both feet being kept on the ground, it bends the trunk on the lower limbs; or if one muscle only be exerted, it twists the body inwards upon the thigh.

The principal antagonist to this Muscle, and by which the thigh is extended or brought back upon the trunk, is found on the back and lower part of the pelvis, and covering the greater part of the outlet. It is the largest Muscle in the body, and is called the

*M. Gluteus Maximus* (Pl. VII. xxxix.; Pl. VIII., fig. ii. b.). It arises from the back of the posterior spinous processes of the hip-bone, from the back of the rump-

bone, from the coccygeal bone, and from the sacro-ischiatic ligaments, over the inner edge of which it is folded. It consists of numerous bundles of fibres, which are loosely connected but together form a very wide and thick Muscle. These pass outwards and downwards, collecting into a very strong, wide tendon, which runs over the back of the great trochanter, and descends to be inserted below it into the upper outer limb of the linea aspera for nearly one-third of the length of the thigh, and is confounded with the broad sheath. *Use.*—Besides extending the thigh, it twists it outwards upon the pelvis; but if the foot be fixed on the ground, and only one Muscle acts, it twists the trunk backwards upon the thigh. The principal use of this Muscle, however, is to preserve the erect position of the trunk upon the Lower Limbs, and it is for this reason that in Man it is larger than in any other animal; and hence arises that peculiar fulness of the buttock in the human subject which is found in him alone throughout the whole of the Animal Kingdom. In every position and motion of the body on the lower extremities, or of them upon the body, it is called into action, except in the recumbent posture; for even in sitting it counteracts the slight tendency to falling forwards which still exists, though not to the same extent as when the body is erect. Between this great Muscle and the back of the pelvis, and partially covering one another, are six Muscles, all of which, excepting one, tend to twist the thigh outwards even when at rest; and by so doing turn the toes outwards, and increase the base of support afforded by the feet. They also draw the head of the thigh-bone tightly into the hip-socket, and antagonize other strong Muscles, presently to be mentioned, which draw the thigh inwards, and steady the pelvis upon the lower limbs.

The largest two of these Abducting Muscles, as they are called, are placed entirely on the back of the pelvis. The first is the

*M. Gluteus Medius* (Pl. VIII. fig. II. c.), which arises from all the back surface of the hip-bone above the semicircular ridge, which, beginning from the superior anterior spine, and running into the ischiatic notch, it collects into a stout tendon, which is inserted into the outer and back part of the great trochanter of the thigh-bone.

*M. Gluteus Minimus* (Fig. III., d.) arises below the semicircular ridge on the back of the hip-bone, descends into a short stout tendon, which is inserted into the fore and upper part of the great trochanter.

The former of these Muscles twists the top of the thigh-bone outwards, whilst the latter assists the *Tensor Vaginæ* to twist it inwards.

Below the Least Gluteal Muscle, a slender Muscle is seen emerging from the cavity of the pelvis, through the great sacro-ischiatic notch. This is the

*M. Pyriformis* (Fig. IV. and III. e.), which originates from the front of the middle three pieces of the rump-bone by as many slips, which coalesce; and, forming a single flattish Muscle, pass from the pelvis, sending out a long slender tendon to be inserted into the top of the trochanteric pit.

Through the little sacro-ischiatic hole another flat tendon is seen emerging from the pelvis. It is that of the

*M. Obturator Internus* (Fig. IV., f.), which, arising from the whole margin of the thyroid hole, and the back of the ligament by which it is filled, descends to pass out of the hole, forming a tendon to be inserted into the trochanteric pit below the last Muscle, but separated from it by the upper head of the next Muscle,—the

*M. Gemini* (Figs. III. and VI. g.), which arises from the spinous process, and the lower head from the tuberosity of the haunch-bone. The two heads run horizontally outwards, enclosing between them the tendon of the last Muscle, and are inserted with it into the lower part of the trochanteric pit.

Below the last Muscle is another of a square shape, and hence called the

*M. Quadratus Femoris* (Fig. III. and V. h.), which arises from the outside of the ischiatic tuberosity, and passing outwards is inserted into the quadrate line, between the two trochanters.

If its upper edge be turned down, the tendon of another abducting Muscle, the

*M. Obturator Externus* (Fig V. i.) is seen. It arises from the margin of the thyroid hole, and from the front of the thyroid ligament. Its fibres pass downwards and outwards, collect into a tendon which runs between the lower edge of the acetabulum and the ischiatic toberosity outwards and backwards, to be inserted into the trochanteric pit just below the *M. Gemini.* Its *Use* is similar to that of the preceding Muscles.

The Adducting Muscles which antagonize those just described consist of a large mass occupying the inside of the thigh, and forming two Muscles, one single and one three-headed Muscle.

*M. Pectineus* (Fig. I. j.).—This arises on the upper inner part of the thigh, from the front of the body of the share-bone, passes outwards and downwards, and is inserted by a broad flat tendon into the upper inner part of the linea aspera.

*M. Triceps Adductor Femoris* (Fig. V. k.).—This very large Muscle forms the principal fleshy mass upon the inside of the thigh, from the pubic symphysis and arch to the knee. It consists of three portions—the *long one*, arising by a rounded tendinous head from the upper part and symphysis of the share-bone; the *short one* from the front of the branch of that bone; and the *large one* from the same branch, and from the ischiatic branch and tuberosity, by a very fleshy and extensive origin. The three portions may be readily distinguished, and though their tendons become ultimately confounded, they are said to be inserted—the *large portion*, tendinous, into the whole length of the linea aspera, and by a rounded tendon into the inner condyle, and the other two also into the linea aspera in front of the former by flat tendons, the *long portion* into the middle, and the *short one* above it, and into the little trochanter behind the *M. Pectineus.*

When the feet are firmly fixed to the ground, and both the just-mentioned Muscles of both limbs, especially the latter, act, they fix the pelvis and prevent it swaying to either side precisely in the same manner as the mast-head of a ship is stayed. If one foot only rest on the ground, these Muscles pull the pelvis downwards and slightly backwards on that thigh; but if the Muscles of the elevated limb act, they bring the thigh upwards, inwards, and forwards, turning the knee outwards at the same time on the supporting limb. If parts of these Muscles act, the *M. Pectineus* will bring the thigh inwards and forwards, and the *large portion* of the *M. Triceps* inwards and backwards.

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The other Muscles of the thigh are seven in number, all acting upon the leg, but some of them connect the leg directly with the pelvis.

*M. Quadriceps Extensor Cruris.*—(Pl. VI. B. C. D.)—This is most commonly, though not very properly, described as four distinct Muscles, by the names of *M. Rectus*, *Vastus Internus* and *Externus*, and *Crureus*; really, however, they form but one four-headed Muscle, occupying the front and sides of the thigh. The *long head* (*M. Rectus*) arises by two short tendons, not exceeding an inch in length, the one from the inferior anterior iliac spine, and the other from the back of the hip-bone just above the hip-socket; they soon unite into a very strong tendon, which, passing downwards towards the front of the thigh, bellies out into a large and powerful Muscle, occupying the middle three-fifths of the limb, and becomes tendinous below. The *short head* (*M. Crureus*) commences its origin immediately below the ridge, running in front from one trochanter to the other, and continues arising from the whole front of the thigh-bone nearly as low as the articular surfaces on the condyles, whence it runs into the back and lower part of the tendon of the long head. The *outer head* (*M. Vastus Externus*) is a very enormous muscular mass arising tendinous and fleshy from the fore and outer part of the root of the great trochanter, from the whole outer edge of the linea aspera, and below becomes partially confounded with the short and long heads. The *inner head* (*M. Vastus Internus*) commences from the front of the root of the less trochanter, and continues arising from the whole length of the inner edge of the linea aspera; its fibres pass forwards, and at the lower part are confounded with the long and short heads. The coalition of the lower ends of these four muscular pieces forms a broad tendon, which is inserted into the base and sides of the knee-cap, the stoutest and thickest part being formed by the long and short portions which are connected with its base, whilst the inner and outer form thin tendinous expansions which spread upon the fore and lateral parts of the knee-joint prior to their insertion into the knee-cap. *Use.*—The principal and most important action of this Muscle is to extend or straighten the leg upon the thigh, whilst its long head may or may not at the same time flex the whole limb upon the trunk; it is therefore a very important Muscle in progression by carrying the leg and foot forwards, when the limb is raised from the ground; but if the foot be fixed, its tendency is to pull the trunk forwards upon the thigh by its long head. It is also the Muscle by which we are raised from the sitting to the erect posture, the action then commencing from the insertion instead of the origin of the Muscle.

The antagonists to this large Muscle are four, situated on the back of the thigh, extending, all excepting one, between the ischiatic tuberosity and the leg.

*M. Semi-tendinosus* (Pl. VII., XLII; Pl. VIII., fig. VI. m.) originates from the back and upper part of the tuberosity by a tendon in common with another Muscle, descends some little distance, and then forms a large muscular belly, which, as it passes down the back of the thigh, inclines towards the inside, and throws out a tendon which, passing behind the inner condyle and around the head of the tibia, is inserted by a broad expansion into the inner and fore part of that bone opposite the tubercle. *Use.*—It bends the leg upon the thigh and extends the thigh upon the pelvis; if the other leg be lifted from the ground, it also pulls the pelvis a little downwards towards the thigh.

*M. Semi-membranosus* (Pl. VII., XLIII.; Pl. VIII., fig. VI. n.)—though thus named, is more tendinous than the preceding, it arises from the back and under part of the ischiatic tuberosity by a flat tendon, which, in the middle of the thigh, forms a short but bulky muscular belly, and through the lower third again becomes tendinous, and its flat tendon accompanying that of the preceding behind the inner condyle is inserted into the back of the head of the tibia. *Use.*—Similar to that of the last.

*M. Biceps Flexor Cruris.*—(Pl. IV., XLI.; Pl. VIII., fig. VI. o.)—The *long head* of this double-bellied Muscle arises from the ischiatic tuberosity in common with the *M. Semi-tendinosus*, descends a short distance, and then forms a fleshy belly which passes down along the outside of the thigh, and just above the outer condyle forms a flat tendon receiving the *short head* which arises from the outer lower third of the linea aspera; the joint tendon passes behind the outer condyle, forms the outer hamstring, and is inserted into the process at the top of the fibula. *Use.*—It bends the leg upon the thigh, extends the thigh upon the pelvis, and, if the other leg be raised from the ground, tilts the pelvis rather outwards and backwards.

The fourth flexing Muscle is short, and acts only upon the leg and thigh; it is situated on the back of the knee-joint, and called from this circumstance

*M. Popliteus.*—(Pl. VIII., fig. VII. p.)—It arises by a short strong tendon connected with the posterior ligament of the knee-joint from the inside of the outer condyle, becomes fleshy as it passes inwards across the ligament, expands as it descends, and is inserted into the back of the head of the tibia, above the linea poplitea. *Use.*—It only flexes the leg on the thigh, or the thigh on the leg.

Two other Muscles still remain undescribed upon the thigh.

*M. Gracilis*—(Fig. VI. q.) a delicate flat Muscle—arises by a broad, thin, tendinous origin from near the pubic symphysis, it continues down the inside of the thigh as a long thin flat Muscle, which behind the inner condyle sends a delicate tendon to be inserted into the inner and fore part of the head of the tibia below its tubercle, and covered by the insertion of the following Muscle. *Use.*—It principally serves to draw the leg inwards towards its fellow, and thus assists the great Adducting Muscles.

*M. Sartorius.*—(Pl. VI., W.; Pl. VIII., fig. I. r.)—This is also a flat muscle, and is the longest in the body; it originates from the superior anterior spine of the hip-bone, in company with the *M. Tensor Vaginæ*, soon becomes fleshy, runs downwards, forwards, and inwards to the lower third of the thigh, whence it passes behind the inner condyle, becomes tendinous, winds round the head of the tibia, then expands and forms a broad tendon, which is inserted below the tubercle, covering the insertions of the *M. Gracilis* and *Semi-tendinosus*. *Use.*—It flexes the leg and thigh upon the pelvis, and at the same time draws the knee forwards and upwards so as to cross the opposite thigh, producing the position called sitting cross-legged, which, being usually employed by tailors, has given rise to its name.

The Muscles on the front of the Leg are covered by a tendinous expansion, called

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The *Anterior Tibial Sheath*, which commences above from the rim of the outer hollow of the shin-bone, and from the front of the head of the splint-bone; it passes down the front of the leg, is connected on the inner side with the whole spine of the shin-bone, and on the outer side, dipping between the Common Long Extensor of the Toes and the Peroneal Muscles, is attached to the front ridge of the splint-bone; at the lower part of the leg it is continued from one ankle to the other, and there commonly, but improperly, called the *Transverse Ligament of the Ankle*; it is continued on the instep, where it is ultimately lost in the cellular tissue of that part.

The Muscles which form the fleshy parts of the Leg may be arranged into two sets: 1st, those which operate upon the foot alone; 2nd, those which act directly upon the toes, and intermediately upon the foot; of the former there are *six*, and of the latter *four* to each foot, and they are placed in relation to each other as follows, —upon the front and side of the leg five, and on its back five.

Upon the front and next to the shin-bone, in the outer hollow surface of which it lies, is the

*M. Tibialis Anticus.*—(Pl. VIII., fig. VIII. s.)—This arises from the outer under part of the head of the shin-bone, and from the upper two-thirds of its outer surface, from the fore and inner part of the interosseous ligament, and from the inner surface of the crural fascia; the fibres thus derived terminate in a strong tendon which passes down in front of the base of the bone, inclines inwards over the instep, and is inserted into the inside of the inner cuneiform and of the base of the metatarsal bone of the great toe. *Use.*—It bends the foot upon the leg, at the same time inclining its inner edge upwards.

To the outer side of the just-named Muscle is the

*M. Extensor Longus Digitorum Pedis* (Fig. VIII. t.), which, commencing from the under outer part of the head of the shin-bone, close to the origin of the last Muscle, arises also from the whole length of the front of the splint-bone, and from the interosseous ligament; its fibres run downwards and forwards into a tendon, which, passing over the outer and fore part of the ankle-joint, continues on the instep and divides into four tendons, which, spreading over the upper surfaces of the outer four toes, are inserted on their extreme phalanges. *Use.*—It extends or elevates the toes upon the upper surface of the foot, and, if its action be continued, bends the foot upwards upon the leg.

Covered by the last Muscle is the

*M. Extensor Proprius Pollicis* (Fig. VIII. u.), which arises from the inner and fore part of the two lower thirds of the shin-bone, and from the interosseous ligament; its fibres run inwards and forwards into a tendon, which, passing over the front of the ankle, runs across the instep inwards, along the upper surface of the great toe, and is inserted into its second piece. *Use.*—It extends the great toe upon the foot, and bends the foot upon the leg.

Upon the upper or dorsal surface of the foot is the

*M. Extensor Brevis Digitorum Pedis* (Fig. IX. v.), which, originating from the fore and outer surface of the heel-bone, runs inwards and forwards over the instep, dividing into four delicate bellies, which send out each a tendon to be inserted into the first row of bones of the inner four toes. *Use.*—It merely extends the toes upon the foot.

On the outside of the Leg are two Muscles, the

*M. Peronei* (Fig. VIII. w. x.).—One of them, the *M. Per. Longus*, arises from the head and from the outer upper half of the splint-bone, it descends and gives off a long and strong flat tendon, which passes behind the outer ankle in a groove; the other, the *M. Per. Brevis*, originates from the lower outer half of the splint-bone, and also sends out a strong flat tendon which passes behind the outer ankle, and to this point it is covered by the long Muscle and its tendon. A little below the ankle the two tendons separate; the long tendon enters the groove in the under surface of the cuboid bone, crosses the sole of the foot close to the tarsal bones, and is inserted into the inner under part of the inner cuneiform bone and the base of the tarsal of the Great Toe, just below the insertion of the Anterior Tibial Muscle. The short tendon runs forwards along the outer margin of the foot, and is inserted into the base of the metatarsal bone of the little toe. *Use.*—The primary use of these Muscles is to elevate slightly the outer margin of the foot, to assist in extending the foot upon the leg, and when extending to rotate the foot outwards upon the ankle-joint. But the Long Peroneal Muscle serves a much more important office, assisted by the Anterior Tibial Muscles, for these two Muscles preserve the lateral arch of the foot when that member rests upon the ground, and when in stepping forward the weight of the body is thrown upon the foot; in consequence of the close insertion of these two Muscles, their tendons act as an elastic sling upon which the middle of the foot rests, and thus materially assist the great Muscles of the calf of the leg and those belonging to the toes, which are more commonly described as bearing the weight of the body.

The Calf of the Leg, as it is commonly called, consists of two very large and muscular bellies, which join together below in a very powerful tendon, commonly called the *Tendo-Achillis*; these two bellies are usually described as distinct Muscles, and are called the external and internal, but it is really only a three-headed Muscle, and may therefore be named only the

*M. Gastrocnemius.*

The *outer* or *posterior belly* (Pl. VII., XLVII.) is the largest: it commences by two tendinous and muscular origins above the back of the tibial articular surfaces, on the condyles of the thigh-bone, and firmly connected with the posterior ligament of the knee-joint, upon the back of which they pass separately, increasing in size and approximating as they descend, till at last they coalesce and form the large broad muscular mass specially called the Calf of the Leg; a sort of seam, however, indicates the distinction between the two pieces, which is rendered more distinct at their lower part, where a broad flat tendon is produced, the middle part of which ascends like a short narrow spear head to this seam.

The *inner* or *anterior* belly (Pl. VIII., x.) arises from the back of the head of the splint-bone, and from the upper outer half of the same bone, also from the shin-bone along the lower edge of the popliteal line beneath the insertion of the Popliteal Muscle; its surface is principally tendinous, and the muscular part diminishes as it passes down below the middle of the leg to join the tendinous expansion of the outer belly. The strong tendon arising from the junction of the bellies narrows as it descends, but increases in thickness from

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 behind to before, and is inserted into the upper and back part of the tuberosity of the heel-bone. *Use.*—If the foot be kept at its usual rectangular position when at rest, the outer belly bends the leg upon the thigh; but if that position is not preserved, both bellies at once extend the foot upon the leg; and if the toes be kept fixed upon the ground by other Muscles, it elevates the heel, and consequently raises the body from the ground. It is therefore the great antagonist of all the Muscles which bend the foot upon the leg, and of those which extend the leg upon the thigh.

A very delicate little Muscle, which has the longest tendon in the body, viz., the

*M. Plantaris* (Fig. VII. z.), commences by a small tendon from above the back of the outer condyle, forms a small belly running upon the back of the knee joint, and as it descends into the leg sends off its slender tendon, which, passing between the two bellies of the Gastrocnemial Muscle, emerges from them below, and, running upon the inner margin of the Tendo-Achillis, is inserted into the inner and back part of the tuberosity of the heel-bone. *Use.*—Principally to turn the inside of the heel upwards, and also to assist in elevating the heel from the ground.

Beneath the last-mentioned Muscles the tendinous *Posterior Tibial Sheath* is observed, commencing from the lower edge of the popliteal line, and attached from the head of the splint-bone downwards along the whole length of its outer margin, and on the inner side throughout the whole length of the shin-bone, below the termination of the popliteal line, to the bottom of the leg; on the outside it becomes confounded with the sheath of the Peroneal Muscles behind the outer ankle, and on the inner side it is lost in the tendinous bridge which gives origin to the Abducting Muscle of the Great Toe. This sheath includes three Muscles, which lie close to the interosseous ligament and the bones. The middle and longest of these is the

*M. Tibialis Posticus* (Fig. IX. b.), which arises from the upper inner and back part of the splint-bone; from the back of the shin-bone below the popliteal line, and from a considerable part of the back of the interosseous ligament, towards the lower part of the leg; these fibres run into the middle tendon, which continues downwards, inclining inwards, and enters the groove at the back of the inner ankle, whence it passes into the foot close to the tarsal arch, to be inserted by several distinct slips into the under surfaces of all the tarsal bones, except the heel-bone; the slip to the navicular bone being the largest. *Use.*—It extends the foot upon the leg; also turns the inner edge of the foot upwards, and assists in supporting the transverse arch of the foot.

*M. Flexor Longus Digitorum Pedis Perforans* (Fig. IX. a.) is situated on the inner and back part of the leg; begins to arise from the back of the shin-bone at the lowest point of the popliteal line, continues its origin some way down, and then sends out a tendon, which at first runs along the inner edge of the tendon of the Posterior Tibial Muscle, but having reached the back of the ankle-joint crosses behind it, and entering the sinuosity of the heel-bone is continued into the middle of the sole of the foot, between the Interosseal Muscles above and the Short Flexor of the Toes below, where it receives a fleshy mass called the *M. Flexor Digitorum Accessorius* (fig. X. c.), which arises from the outer part of the astragalo-calcaneous ligament, and from the front of the heel-bone itself, and runs into the outer posterior edge of the tendon of the Long Flexor, which immediately divides into four slender tendons; these pass forwards to the outer four toes, and entering the digital sheaths perforate the tendons of the Short Flexor, and are inserted into the under surface of the tips of the extreme bones of the same toes. From the inner edge of each of these tendons, immediately after the division of the principal tendon, arises a small Muscle, in shape like a worm, and hence called *M. Lumbricales*. These send out each a small slender tendon, which spreads out and is inserted into the inside of the first bone of the corresponding toe, and run into the tendons of the Extensor Muscle. *Use.*—The Long Flexor Muscle is an important agent in progression; it bends the toes into the sole of the foot, and consequently grasps the ground, hooking the toes into it so as to make them the resisting point from which the body is jerked forward in procession; in which office it is materially assisted by the Short Flexor, hereafter to be described. In uncivilized people, by whom the foot is not mechanically confined, the action of these Muscles is much more extensive and powerful than among ourselves, whose feet are encased in shoes, which become greater impediments in proportion to the thickness of their soles. Another function of the Muscle is to extend the foot, and if the toes be fixed on the ground it helps to support the body on tiptoe. 

The Accessory Muscle either assists the Long Muscle in grasping, at which time it may be accounted as a second head, or if the Long Muscle be inactive it operates upon its short tendons, which then serve the purpose of tendons to the Accessories. The Lumbricales incline the toes to which they are attached inwards.

*M. Flexor Longus Pollicis* (Fig. IX. d.) is situated on the outer edge of the Posterior Tibial, and is the most bulky and powerful of the deep Muscles at the back of the leg. It arises by two thick sets of fibres from the lower back and outer surface of the Splint-bone; these run into a middle tendon, which runs into the sinuosity of the heel-bone between it and the astragalo-calcaneous ligament, and having got fairly into the sole of the foot crosses above the tendon of the Long Flexor of the toes, and reaching the inner side of the foot passes on the under surface of the Metatarsal bone and the two bones of the great toe, to be inserted into the top of its second piece. *Use.*—It bends the Great Toe into the Sole, and is most important in progression; by it the Great is the first of the Toes which grasps the ground, and in consequence of the length of that member, as the foot and other toes are raised from the ground the whole weight of the body is ultimately borne upon it, till in the end it jerks the whole trunk forward. It also extends the foot upon the leg. But it mainly assists in supporting the transverse arch of the foot; for, passing through the sole from without inwards, it crosses the tendon of the Long Flexor of the Toes, which runs from within outwards: the result of this is, that whilst the latter draws the outside of the Sole inwards, the former draws the inside outwards, and thus the splaying out of the foot by the weight of the superjacent body is prevented. The crossing of the tendons of these two Muscles also forms a second kind of sling, not so perfect indeed as that of the Anterior Tibial and Long Peroneal Muscles, by which the weight of the body is in a measure divided between them, even when we stand on the great toe alone.



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The tendons of the last described three Muscles, as well as those Muscles which are situated in the sole of the foot, are not visible till the removal of a large tendinous expansion, the

*Plantar fascia*, which originates by a thick mass from the under part of the tuberosity of the heel-bone; it consists of fibres, the greater number of which run lengthways upon the sole of the foot, but are connected by many which interlace transversely with them. Soon after its origin it divides into three portions, of which the *middle portion* is the thickest, strongest, and most extensive; it occupies the middle of the foot, and rather before the bases of the Metatarsal bones divides into five slips, which make their way towards the roots of the toes and become blended with the digital sheaths. The *outer portion*, which is also strong and thick, passes forward, becomes fixed to the tuberosity of the little Metatarsal bone, and is lost upon the Abductor and Short Flexor Muscles of the little toe. And the *inner portion*, which is very thin, then spreads over the short Muscles of the great toe and is lost upon them.

In the middle of the Sole, besides the Accessory Flexor and the Lumbrical Muscles, already described, is the

*M. Flexor Brevis Digitorum Pedis Perforatus*, which arises, in common with and between the Abducting Muscles of the Great and Little Toes, from the fore and under part of the tuberosity of the heel-bone, and also from the middle portion of the plantar fascia; it sends forwards four slender tendons, perforated by the tendons of the Long Flexor Muscle, and inserted into the under surface of the second phalanges of the four lesser toes. *Use*.—It assists the Long Flexor by bending the second phalanges into the sole, and helps to sustain the longitudinal arch of the foot.

Upon the inside of the Sole are three Muscles belonging to the Great Toe, the innermost of which is the

*M. Abductor Pollicis Pedis* (Fig. xi. f.), which arises fleshy from the inner and fore part of the heel-bone; as it passes forwards becomes tendinous, and is inserted into the outer sesamoid bone.

*M. Flexor Brevis Pollicis Pedis* (Fig. xi. g.) arises to the outer side of the last Muscle from the Heel-bone by one head, and by another from the outer cuneiform bone; its two bellies pass one on each side of the tendon of the Long Flexor Muscle, and are inserted into the sesamoid bones of the Great Toe.

*M. Adductor Pollicis Pedis* (Fig. xii. k.) originates from the fore and under part of the heel-bone, from the outer cuneiform and from the cuboid bone; it forms a large fleshy belly, which is inserted tendinous into the outer sesamoid bone. *Use*.—If the former and latter Muscles act together they assist the Short Flexor in bending the first piece of the Great Toe upon the metatarsal bone; if separately, they abduct or separate from, or adduct or approximate to the other toes the whole Great Toe.

On the outer side of the Sole there are two Muscles belonging to the little Toe.

*M. Abductor Minimi Digiti* (Fig. xi. h.) arises from the under outer part of the tuberosity of the heel-bone, and from the plantar sheath, also from the base of the Metatarsal bone of the little toe; it is inserted into the outside of the first bone of that Toe.

*M. Flexor Brevis Minimi Digiti* (Fig. xi. l.) originates from the front edge of the groove in the cuboid, also from the base of the Metatarsal bone of the little toe; it is inserted into the base of the first bone of the same toe. *Use*.—If the last two Muscles act together they bend the little toe into the sole, but if the former act alone it separates the little from the other toes.

The heads of inner and outer Metatarsal bones are connected by a Muscle called the

*M. Transversalis Pedis* (Fig. xii. j.), which runs across from the outside of the head of the great Metatarsal, receives slips from each of the others as it passes outwards, and is finally inserted into the inside of the little Metatarsal bone. *Use*.—It approximates the heads of all the Metatarsal bones.

Besides the Muscles already described, there are some others called

*M. Interossei* (Fig. xii. l.), which occupy the spaces between the Metatarsal bones, whence they arise, and are inserted into the sides of the bases of the first row of the toe-bones. They are seven in number, four being called *External*, which are bicipital, or having two origins; and the other three *Internal*, which have but a single origin. *Use*.—To bring each toe inwards or outwards towards the side on which they are inserted.

### Of the Muscles of the Upper Extremities.

The Muscles acting upon each Upper Extremity consist of fifty-four: of these eight connect the limb to the Trunk; nine, the Blade-bone to the Upper and Fore Arm; twelve, the Upper Arm to the Fore Arm, Hand, and Fingers; one, the bones of the Fore Arm to each other; six, the Fore Arm to the Hand and Fingers; and eighteen on the Hand connecting its several pieces.

Of the Muscles which connect the Upper Extremity to the Trunk, some are attached to the Shoulder-bones, and others to the Upper Arm.

Of those which connect the Trunk with the Shoulder-bones, three are situated on the back, one on the side, and two in front.

*M. Trapezius* (Pl. VII., III.), so named from its figure, is placed superficially on the back of the Neck and Chest; it begins by a thin fleshy origin from the great external transverse ridge of the occipital bone for about the space of an inch to the outside of its protuberance, also by a strong thick tendon from the protuberance itself, from which point to the sixth cervical spinous process it joins its fellow by cellular tissue, forming what is improperly called *ligamentum nuchæ*, a structure which, in the human body, does not exist; it arises also from the lowest two cervical and from all the dorsal spines excepting the lowest two or three; the upper fibres pass downwards and forwards, forming the outer marginal line of the Neck; the middle fibres run horizontally outwards, and the lower ascend. They are inserted into the upper outer third of the collar-bone, and into the inner edge of the acromion, and the upper edge of the spine of the blade bone. *Use*.—The upper fibres raise the collar and blade bones, or, as it is commonly called, "shrug the shoulders;" the middle fibres draw the blade-bone inwards towards the Spinal column, and the lower draw it downwards.

When the *M. Trapezius* is turned aside, two Muscles are seen,—

*M. Levator Scapulæ* (Pl. VII., XXI.), a long flat Muscle arising by tendinous slips from the uppermost five cervical transverse processes, but sometimes from fewer; it is inserted tendinous and fleshy into the

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 upper angle of the blade-bone, and into all that part of its base which is above the spine. *Use.*—It elevates this angle of the bone, and by so doing tilts the shoulder-joint downwards.

*M. Rhomboideus* (Pl. VII. XXII. & XXIII.), generally described as two Muscles, consists of an *upper narrow slip* and a *lower broad expansion*, the former arising from the two or three lower cervical, and the latter from the upper five dorsal spines by a thin delicate tendon; the fleshy fibres of the Muscle run out horizontally, and are inserted tendinous and fleshy, the upper into the base of the blade-bone opposite its spine, and the lower into the base below the spine. *Use.*—To draw the blade-bones together.

Upon the side of the Chest is placed a large broad Muscle, the

*M. Serratus Magnus* (Pl. VI., t. t. t.), so named from the saw-like appearance produced by the slips which originate from the nine upper ribs, and which mount upwards and backwards to be inserted along the whole anterior edge of the base of the blade-bone. *Use.*—To draw the whole base of the blade-bone forwards and rather downwards, antagonizing the *M. Rhomboideus* and *Levator Scapulæ*, and assisting in bringing the shoulder-joint forwards. The following two Muscles are covered by the *M. Pectoralis Major*, to be presently described.

*M. Subclavius* is of small size, arising by a tendinous origin from the first rib, close to its junction with the cartilage, lies beneath the clavicle, and is inserted into its middle third. *Use.*—It slightly depresses the collar-bone, but its real use is to serve as a muscular ligament by which that bone is firmly connected with the trunk, and greater extent of motion admitted than would be allowed by true ligament.

*M. Pectoralis Minor* is of an irregularly triangular form, its base facing towards the front of the chest, and its apex towards the shoulder; it arises from the three ribs below the second by tendinous and fleshy origins; its fibres collect, run upwards and outwards into a tendon, which is inserted into the coracoid process of the blade-bone. *Use.*—It pulls the shoulder-joint downwards and forwards, and thus antagonizes the *M. Trapezius*.

The two Muscles connecting the Upper Arm with the Trunk are the following:—

*M. Pectoralis Major* (Pl. VI., r.; Pl. IX., fig. II. a.), situated in front of the Chest, and covering the *M. Subclavius* and *Pectoralis Minor*, is a large triangular Muscle, which by its greater development characterizes the male chest, and by its extension into the Upper Arm forms the front boundary of the arm-pit. It arises fleshy from the inner under half of the collar-bone, from both pieces of the breast-bone, and from the cartilages of the fifth and sixth ribs; it covers the fore and upper part of the chest; its upper fibres pass down, its lower up, and the middle transversely outwards, collecting into a thick muscular mass in front of the arm-pit, and, extending to the Upper Arm, is inserted into the fore or outer edge of the bicipital groove. *Use.*—When the arm hangs down it draws it closer to the chest, and also across it and forward; if elevated, it pulls it down and forwards; and if it have been rotated outwards, it returns it to its natural position.

*M. Latissimus Dorsi* (Pl. VII. IV., Pl. IX., fig. II. b.) is the most extensive Muscle in the body, and, like the last, of an irregularly triangular form, its base running along the lower part of the spine, its apex terminating in the Upper Arm, and as it passes from the Trunk forms the hinder boundary of the arm-pit; it arises tendinous from the spinous processes of the rump-bone and the hind part of the hip-bone, from the spinous processes of all the loin, and from four to seven of the lowest back vertebres, and by fleshy and tendinous slips from the lower four ribs; its fleshy mass spreads over the lower and lateral parts of the back and chest, collects as it passes upwards, runs over the back of the lower angle of the blade-bone, whence it is said to receive additional fibres, and then crossing the arm-pit terminates in a broad strong tendon, which is inserted into the inner or hinder edge of the bicipital groove of the upper arm-bone. *Use.*—When the arm hangs down it draws it closer to the side, also across and behind the chest; if elevated it depresses it; and if turned outwards rotates it inwards, assisting the last Muscle in that action, and perfecting it more completely.

Of the Muscles already mentioned, those which connect the Trunk with the collar and blade bones are specially for the purpose of fixing the socket of the shoulder-joint in such position as is most suitable for the performance of the various and varying motions there occurring, and at the same time to steady the socket, though altering its position as occasion may require; on which account it is that the motions of the Upper Arm are much more extensive upon the Trunk than those of the Lower Limb, in which the socket of the hip-joint cannot have its direction changed, from its connexion with the trunk being by such close and short ligaments as to render the hip and rump bones equivalent in this respect to a single bony ring. The other two Muscles which connect the Upper Arm to the Trunk have nothing to do directly with altering or fixing the shoulder-bones, though they do so indirectly, but have merely their connexion with the rump to increase their power by making them longer levers.

There are seven Muscles moving the Upper Arm directly upon the socket of the blade-bone (Pl. IX., figs. I. & II.).

*M. Deltoides* (Pl. VII. v., Pl. IX. fig. I. a.) is the large Muscle covering the shoulder-joint, causing its roundness; it is of a triangular shape with its base upwards, and its basal angles bent towards each other; it arises from the outer under half of the collar-bone, from the outer margin of the acromial process, and the whole under edge of the spine of the blade-bone, tendinous and fleshy; it forms a thick and bulky Muscle, of which the anterior and posterior fibres pass downwards and outwards, and the middle, or those from the acromion, directly downwards, in numerous thick bundles, which diminish in extent but increase in thickness till inserted into the rough surface or deltoid process of the upper arm-bone. *Use.*—This muscle performs various and very opposite motions, and its whole mass never acts simultaneously; its middle fibres, arising from the acromion, raise the arm upon the shoulder-socket, not, however, above the level of the acromion, but this can only be effected by the consent of the clavicular part, and of that portion arising from the scapular spine, both of which, when acting together, strive to pull the arm down to the side; if, however, the middle portion of the Muscle be quiescent, the clavicular part will draw the arm upwards and forwards, whilst that arising from the scapular spine pulls it upwards and backwards



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upon the chest. The arm is also rotated upon the glenoid cavity by the alternate action of the fore and hind parts of this Muscle. The elevation of the elbow vertically above the head is a compound motion, in which the Deltoid Muscle, and indeed only its clavicular portion, bears a part.

Attached to the back and edges of the blade-bone there are three Muscles, which connect it with the great tubercle of the upper arm-bone.

*M. Supra Spinatus* (Pl. IX., fig. 1. d.) is covered by the scapular insertion of the *M. Trapezius*; it fills up the whole of the supra-spinate pit, from whence it arises fleshy, as well also as from the inside of a tendinous expansion, which, running from the spine to the upper edge of the bone, prevents the starting of the Muscle; its fibres collect into a broad flat tendon, which runs over the top of the capsular ligament of the shoulder-joint, with which it is closely connected, and it is inserted into the fore and upper part of the great tubercle. *Use.*—It assists the middle of the Deltoid in raising the arm from the side, and slightly outwards.

*M. Infra Spinatus* (e.) is partially covered by the scapular origin of the *M. Deltoides*, it fills up the whole of the infra-spinate pit, originating by numerous little bundles of muscular fibres, which, as they ascend up to the shoulder-joint, ultimately collect into a tendon, which spreads over the capsule, becomes confounded with it, and is inserted into the middle of the great tubercle. *Use.*—It rotates the arm outwards when hanging against the side, but also assists in elevating it vertically above the shoulder.

*M. Teres Minor* (Fig. II. h.) arises tendinous and fleshy from the middle two-thirds of the lower edge of the blade-bone, between the origin of the long head of the *M. Triceps Extensor*, and that of the *M. Teres Major*; it forms a flat belly, which ascends and terminates in a short stout tendon inserted into the under part of the great tubercle. *Use.*—It rotates the arm outwards; if the Arm be not elevated above the horizontal posture, it antagonizes the middle of the *M. Deltoides* and the *M. Supra-* and *Infra-Spinatus*; but if the arm be raised above that posture, it also helps to elevate it vertically.

The antagonists of these three Muscles, in reference to rotation, are the *M. Pectoralis Major*, *Latissimus Dorsi*, and the clavicular origin of the *M. Deltoides*, already described, together with the two following, viz.:—

*M. Subscapularis* (g.), a very large mass of interweaving muscular fibres which fill up the whole of the subscapular part, and originate from its surface; they collect as they ascend, and are connected to a large broad tendon, which expands over the front of the capsular ligament of the shoulder-joint, and is inserted into the little tubercle of the upper arm-bone. *Use.*—It rotates the arm inwards, and when raised up the horizontal posture assists in elevating it vertically.

*M. Teres Major* (Fig. I. f.) assists the *M. Latissimus Dorsi* in forming the posterior margin of the arm-pit; it arises from the triangular space at the back of the lower angle of the blade-bone, and from the lower part of its inferior margin it forms a straight flat Muscle which passes upwards and outwards, and as it approaches the arm sends out a wide flat tendon which is inserted into the inner or hind edge of the bicipital groove with the tendon of the *M. Latissimus Dorsi*, but anterior to it, and continuing its insertion below it. *Use.*—It approaches the arm to the side, rotates it inwards, and in whatever state of elevation the arm may be, depresses or brings it again to the side.



Of the remaining three Muscles which connect the blade-bone and arm, one only is inserted into the upper and the other two into the fore arm.

*M. Coraco-brachialis* (Fig. II. i., fig. IV. i.) arises tendinous and fleshy from the fore part of the coracoid process; it passes down along the inner part of the upper arm, and is inserted rather above its middle into a ridge, continuing its insertion between the origins of the *M. Brachialis Anticus* before, and of the *Triceps Extensor Cubiti* behind. *Use.*—It brings the arm forwards and upwards upon the chest at the same time, rotating it outwards, and is the Muscle which commences its vertical elevation upon the shoulder-socket; it is, therefore, the antagonist of the *M. Teres Major*.

Upon the back of the arm is a very large Muscle, having three heads or origins, and therefore called

*M. Triceps Extensor Cubiti* (Figs. III. & IV. j.).—Its *upper* or *long head* commences by a flat tendon from the lower edge of the blade-bone, just beneath the glenoid cavity; it passes between the bellies of the two *M. Teretes*, and soon becomes muscular; its bulk is increased by joining with the *middle head*, which commences at the back of the neck of the upper arm-bone, continues its origin from the back and outer part of the bone; these two are soon joined by a third, the *lower* head, which commences its origin near the insertion of the *M. Teres Major*, and continues to arise from the inner and back part of the bone as low as the pit at the back of the cubital pulley for the olecranon. About the middle of the arm the surface of the Muscle begins to be tendinous; the quantity of tendon increases as it descends, and a little above the elbow forms a broad strong expansion, which is inserted into the upper and outer part of the olecranon. *Use.*—By its scapular head this Muscle draws the whole arm back upon the blade-bone, and it also assists the other two heads in extending the fore upon the upper arm, which is the only office they perform. When the arm has been elevated it assists in depressing it.

*M. Biceps Flexor Cubiti* (Fig. II., IV., & V. k. k.) is situated upon the front of the upper arm, and in moderately muscular persons its form and course are distinctly seen; it arises by two heads; the *long head* commences by a slender tendon from the upper edge of the glenoid cavity of the blade-bone, within the ligamentous capsule of the shoulder, but excluded from the joint itself by the reflexion of the synovial capsule; it runs over the top of the upper arm-bone, and emerging from the capsule between the two tubercles, descends along the upper arm in its own peculiar groove, the synovial membrane enveloping it for some distance; soon after its escape from the arm-pit, through which it passes, it forms a large rounded belly, which again becomes tendinous just above the elbow-joint, where it receives the tendon of the *short head*, which has arisen tendinous and fleshy from the coracoid process, in common with the *M. Coraco-Brachialis*, has descended for about a third of its length connected with that Muscle, and then formed its own distinct belly, which lies on the inside of that of the long head, from the lower end of which its tendon is given out. Opposite the bend of the elbow a tendinous expansion is given off, which, spreading over the whole fore arm, descends to the wrist and is lost upon the hand. The

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Anatomy. tendon itself dips down between the flexors of the hand and fingers and the supinators of the fore arm, and is inserted at the inner and back part of the tubercle of the spoke-bone. *Use.*—This Muscle, acting upon the whole arm by its long head, is a principal agent in raising it upright above the shoulder, and by the short head the limb is brought upwards and forwards. It bends the fore upon the upper arm, thereby antagonizing the *M. Triceps Extensor*; and it renders the fore arm and hand supine, which motion may be performed by it when the fore arm is extended, or when it is in any degree bent, or being bent upon the upper arm. When it acts it also tightens the tendinous sheath of the fore arm in the same manner as the *M. Tensor Vaginæ Femoris* acts on the sheath of the thigh.

*M. Brachialis Anticus* (figs. IV. & V. l.).—This large mass of Muscle commences its origin on each side of the insertion of the *M. Deltoides*; it continues arising from the front of the upper arm as low as the pit for the cubital coronoid process; the front of the Muscle below becomes tendinous, more tendon is produced as it expands over the front of the elbow-joint, and it is inserted into the coronoid process of the cubit. *Use.*—It bends the fore upon the upper arm, and has no other action.

Antagonizing the last Muscle is the

*M. Anconeus* (fig. VI. m.), which, originating from the back of the outer condyle of the upper arm, passes inwards and downwards, and is inserted into the outer upper fourth of the cubit. *Use.*—It extends the fore upon the upper arm, but performs no other office.

The Muscles upon the fore arm arise partly from the upper and partly from the fore arm itself; for the most part their muscular bellies do not descend below the middle of the arm, and hence, from the less space occupied by their tendons, the lower is much more slender than the upper part of the fore arm. They are divided into sets, viz., flexors and extensors of the hand, pronators and supinators of the spoke-bone, consequently also of the hand, and long flexors and extensors of the fingers. Of these the flexors and one of the pronators partially arise from the inner condyle of the upper arm-bone; and the greater number of the extensors, and both the supinators, from the outer condyle.

The Flexing Muscles of the Hand are three.

*M. Palmaris Longus*, sometimes wanting, is situated the most superficially, arises tendinous from the front of the inner condyle, has a small fleshy belly which speedily sends out a long tendon; this descends in the front of the fore arm, and is inserted into the palmar sheath, which consists of longitudinal and transverse tendinous fibres, thickest in the upper and middle part of the palm, and attached to the digital sheaths of all the fingers; it is thinner upon the short Muscles forming the ball of the little finger, and thinnest upon the ball of the thumb. *Use.*—It bends the hand upon the fore arm, and assists in pronation.

*M. Flexor Carpi Radialis* (fig. V. n.) arises tendinous from the front of the inner condyle of the upper arm-bone, and also from the fore and upper part of the cubit; about a third of the fore arm downwards it becomes tendinous, and, inclining outwards as it descends, passes behind the annular ligament, is continued through the groove in front of the trapezial bone, and is inserted into the front of the base of the metacarpal bone of the fore finger. *Use.*—It bends the hand forwards and inwards upon the fore arm, and assists in performing pronation. Anatomy.

*M. Flexor Carpi Ulnaris* (fig. V. o.) is situated on the inside of the fore arm, arises tendinous from the inner condyle of the upper arm-bone, and fleshy from the outside of the olecranon; it becomes tendinous on the middle of the fore arm, runs down along the inner and fore part of the cubit, and is inserted into the pisiform bone. *Use.*—It bends the hand upon the fore arm.

The extending Muscles of the Hand are also three.

*M. Extensor Carpi Radialis Longior* (fig. VI. p.) is situated on the outer and back part of the fore arm, covered partially at its origin by the *M. Supinator Longus* (a.), to be hereafter described; it arises by a broad fleshy origin from the ridge above the outer condyle of the upper arm, is fleshy for some distance, then sends out a strong flat tendon, which, passing close to the spoke-bone, is continued through the groove at its base, and is inserted into the back of the base of the metacarpal bone of the fore finger.

*M. Extensor Carpi Radialis Brevior* (fig. VI. q.) has its muscular part covered by the last Muscle, arises fleshy from the outer condyle of the upper arm-bone, and from the brachio-radial ligament; about the middle of the fore arm sends off its tendon, which, passing to the inner side of the preceding, is inserted into the back of the base of the middle metacarpal bone. *Use.*—The two last described Muscles extend the hand upon the fore arm.

*M. Extensor Carpi Ulnaris* (fig. VI. r.) arises tendinous from the back of the outer condyle of the upper arm-bone, immediately external to the *M. Anconeus*, becomes fleshy, and having reached the lowest insertion of that Muscle obtains some fleshy fibres from the outer and back part of the cubit; near the lower part of which it gives off its strong tendon, which is continued in the pit on the outside of the cubital styloid process, and is inserted into the upper and back part of the base of the innermost metacarpal bone. *Use.*—It extends the hand upon the fore arm.

The proper Pronator Muscles of the Hand, operating on it through the medium of the spoke-bone, are two:

*M. Pronator Radii Teres* (fig. VII. a.) arises from the inner condyle, the outermost of all those which arise from it; it also originates from the coronoid process of the cubit: its fibres pass downwards and outwards, become tendinous, and the tendon is inserted into the outer and back part of the middle of the spoke-bone. *Use.*—Besides its proper action, it also flexes the fore upon the upper arm.

*M. Pronator Radii Quadratus* (fig. VII. b.), at the lower and fore part of the fore arm, and covered by all the tendons of the Flexor Muscles of the fingers; it arises tendinous and fleshy from the inner and fore part of the cubit; is a square Muscle, as its name implies; its fibres pass outwards, and it is inserted into the outer edge of the spoke-bone. *Use.*—It only renders the hand prone.

Besides these two, all the Muscles originating from the inner condyle, except the *M. Flexor Carpi Ulnaris*, indirectly tend to render the hand prone.

Their direct Antagonists are also two:

*M. Supinator Radii Longus* (fig. VI. a.): this covers all the Muscles arising from the outer condyle of the upper arm-bone and the ridge above it; its origin is fleshy and broad from the commencement of the outer

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condylar ridge as high as the middle of the bone; its fleshy belly assists in making up the fullness on the outside and immediately below the outside of the elbow-joint; about the middle of the fore arm it sends out a flat tendon, which running close to the outside of the Spoke-bone is inserted into the outside of its base. *Use.*—Besides its proper use, when the hand is prone it assists in extending the fore upon the upper arm.

*M. Supinator Radii Brevis* (fig. VI. b.); this Muscle is deeply situated, and covered by the three Muscles at the outside of the elbow, viz., the last mentioned, and the two radial extensors; it arises from the outer condyle itself, and from the brachio-radial ligament; it passes downwards and inwards, and becoming tendinous and fleshy is inserted into the fore and inner part of the spoke-bone from its neck down to the insertion of *M. Pronator Radii Teres.* *Use.*—Similar to the last.

Besides these, the extensors of the fingers and thumb, especially those of the latter, assist in performing supination.

The Long Flexors of the Fingers consist of two to the Fingers and one to the Thumb.

*M. Flexor Digitorum Sublimis Perforatus* (fig. V. a.) arises from the inner condyle of the upper arm, between the Radial and Ulnar Flexors; also from the coronoid process of the cubit, and from the spoke-bone, just by the insertion of the *M. Supinator Radii Brevis*; about the middle of the fore arm it exhibits four muscular bellies, not of large size however, and these send out as many tendons, which descending behind the transverse ligament of the wrist pass through the hand on the first row of the digital pieces, are perforated by the following Muscle, and are inserted by two slips each into the second row of digital pieces. *Use.*—Primarily, they bend the second joints of the fingers into the hand; and, secondarily, the hand upon the wrist.

*M. Flexor Digitorum Profundus Perforans* (fig. VIII. b.) is situated close to the cubit and inter-osseous ligament, and more especially covered by the last Muscle; it arises from the cubit, between its coronoid process and the origin of the *M. Pronator Radii Quadratus*, and also from the front of the ligament, fleshy; it forms four strong tendons, which pass behind and rather to the inner side of the last, and descending behind the transverse ligament of the wrist enter the hand, continue through the palm, pass into the digital sheaths, by which they, as well as those of the last Muscle, are prevented from starting, and perforating their tendons are inserted into the fronts of all the third row of digital pieces. *Use.*—This Muscle bends the third joints of the fingers upon the others, and the whole of the fingers into the hand; it also bends the hands upon the fore arm.

In the palm of the hand, and from the outer side of each of these tendons, originate the

*M. Lumbricales* (fig. IX. c. c. c.), four in number, like as many earth-worms, which, passing onwards, are inserted by their tendons into the outer side of the first row of digital pieces. *Use.*—They bend the first joints and incline them outwards.

*M. Flexor Longus Pollicis* (fig. VIII. d.), which arises by a fleshy origin from the front of the spoke-bone, between its tubercle and the insertion of the *M. Pronator Quadratus*; it has also commonly a very small slip or little belly derived from the inner condyle of the upper arm-bone; at the termination of its origin it gives off a tendon, which passes behind the transverse ligament into the hand, and running along the inside of the metacarpal bone of the thumb and its two digital pieces is inserted into the extreme one. *Use.*—It bends the thumb into the palm, and assists in bending the hand upon the fore arm.



On each side of the tendon of the last Muscle, as it runs along the metacarpal bone, is situated the

*M. Flexor Brevis Pollicis* (fig. V. e.), consisting of two bellies, the outer one arising from the front of the trapezoid, and the inner from the great and unciform bons; and each of these is inserted either in the sesamoid bones, usually existing at the first joint, or into the edges of the base of the first digital piece. *Use.*—It bends the first joint on the metacarpal bone, and that bone upon the trapezial bone.

The Extensors of the Fingers are also five, three of which belong to the Thumb.

*M. Extensor Digitorum Communis* (fig. VI. f.) arises from the back and outer part of the outer condyle of the upper arm-bone to the outside of the origin of the *M. Extensor Ulnaris*, and is connected with that of the *M. Supinator Brevis*; it is not a very powerful Muscle, but about the middle of the arm sends out four tendons, which pass over the back of the wrist and hand, on the latter of which they are usually connected by oblique tendinous slips, are then continued to the backs of the fingers, upon the whole of which they spread, and are inserted into the last digital pieces. Sometimes a fifth belly, then called *M. Extensor Proprius Minimi Digiti*, springs from the cubit alone, and is inserted into the little finger. *Use.*—To extend all the fingers.

*M. Extensor Ossis Metacarpi Pollicis* (fig. VI. g.) arises from the outer and back part of the cubit, from the inter-osseous ligament, and from the inner and back part of the spoke-bone; as it descends it is crossed by the Radial Extensors; its tendon runs along the outside of the base of the latter bone through its uttermost groove, and is inserted into the back of the trapezial and of the base of the metacarpal bone of the thumb.

*M. Primi Internodii Pollicis* (fig. VI. h.) originates below the preceding from the cubit and the interosseous ligament; its tendon accompanies the last, runs along the outside of the metacarpal bone, and is inserted into the outside of the first digital piece.

*M. Secundi Internodii Pollicis* (fig. VI. i.) arises from the same parts as the last Muscle, but below them; its tendon is crossed by the Short Radial Extensor; it runs through the little deep groove at the back of the base of the spoke-bone, and it is inserted into the outside of the base of the second digital piece of the thumb. *Use.*—All these three Muscles extend those parts of the thumb to which they are attached; the first of them, however, only the metacarpal bone, but the last the whole thumb. They also bring the thumb back towards the back of the hand when it has been brought forward by the *M. Flexor Ossis Metacarpi*; and all assist in supination of the hand.

Three other Muscles of the Thumb, also short ones, remain to be described.

*M. Abductor Pollicis* (fig. VIII. j.), situated on the outside of the ball of the thumb, arises tendinous from the transverse ligament, and from the trapezial bone; it is inserted into the front of the root of the first digital piece of the thumb.

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*M. Flexor Ossis Metacarpi Pollicis* (fig. IX. k.*), beneath the former, has also the same origin: it is inserted into the fore and under part of the metacarpal bone of the thumb.

*M. Adductor Pollicis* (figs. V. & IX. k.) is a broad triangular Muscle originating from the whole length of the front of the middle metacarpal bone; it collects together as it passes downwards and outwards to be inserted tendinous into the back of the base of the first digital piece of the thumb. *Use.*—The former of these Muscles carries the thumb outwards and forwards from the palm; the second bends the metacarpal bone towards the wrist; and the third draws it inwards and backwards into the palm.

The Little Finger has also three Muscles; by one of which it is bent into the palm, by the second drawn inwards from the other fingers, and by the third outwards towards them.

*M. Abductor Minimi Digiti* (fig. IX. l.) arises tendinous from the pisiform bone and transverse ligament; it forms a fleshy belly on the inside of the palm, and is inserted into the inside of the base of the first digital piece.

*M. Flexor Proprius Minimi Digiti* arises from the transverse ligament and from the hook of the unciform bone; it is inserted into the root of the first phalanx of the little finger.

*M. Adductor Minimi Digiti* (fig. IX. m.) is covered by the last Muscle, and has the same origin; it is inserted into the whole length of the inner and fore part of the metacarpal bone of the little finger.

Between the metacarpal, as between the metatarsal bones, there are also short Muscles called

*M. Interossei*, seven in all; of these the four *anterior* or palmar ones are single-headed, and the three *posterior* are double-headed; their thin tendons are inserted on the sides of the first row of digital pieces. *Use.*—To bring each finger inwards or outwards towards that side on which they are inserted.

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# ANATOMY.

## SECTION III.

### OF THE SENSES.



The *general* properties and functions of the Brain and Nerves having been already considered,* the Anatomy and appropriate or *specific* Physiology of the Organs of Sense remain to be treated of under the present head. The senses may be defined as those organs by which external impressions are received and conducted to the Sensorium; each sense, therefore, consists of a recipient surface and propagating medium. To the constitution of a perfect organ the following essentials must be present:—1. A special nerve; 2. An appropriate stimulus from without; 3. A capacity on the part of the former (the nerve) to appreciate the specific influence of the latter (the stimulus). Thus it will be perceived that the *Nerve* is the fundamental part of the sense, whilst the so-called *organ* merely presents a surface for the extension of the nervous matter, and a mechanism more or less complex for the modification of external impressions. It is not difficult to trace the operation of appropriate impressions on the various Organs of Sense, but it is quite beyond the limit of our present knowledge to follow them further; and all the theories which have been broached to throw light on this subject amount to little else than idle speculation. Observation and experiment have enabled the physiologist to isolate (or nearly so) those parts of the brain which are associated with the external senses (see ANATOMY OF THE BRAIN); but this knowledge affords him no clue to the intricate problem above alluded to. Before concluding these introductory observations, the reader should be reminded that what we denominate "Sound" and "Light," "Odours" and "Tastes," have no abstract existence: the conditions necessary for the production of these effects may exist, but the effects themselves are recognized only in connexion with appropriate organs to receive and communicate the impressions: thus, no words can convey the idea of what light is to the blind; nor can the deaf man form an adequate notion of what is meant by sound. Lastly, it may be remarked that all impressions made on the Senses are more or less transient in themselves, *i. e.*, the *material* effect does not long survive the cause. It is only when the mysterious boundary is passed, and impressions become acknowledged and associated by the *immaterial* part of our nature, that they assume a permanency which converts them into materials that constitute the fabric of all our knowledge.

The Senses are five in number: they will be described in the order of enumeration;—Smell, Taste, Touch, Hearing, and Sight. In each instance the description of the mechanism of the organ will be succeeded by that of its nervous and vascular organization, and its physiology.

* 'Nervous System,—Structure and Physiology,' p. 151.

ORGAN OF SMELL.—The Nose, properly so called, constitutes but a small portion of the organ by which odours are perceived. It is more or less prominent and pyramidal in form, projecting from the face between and below the eyes and above the mouth. It is composed of bones, cartilage, mucous membrane, and common integument. The external aperture is divided, not always symmetrically, by a central cartilaginous septum. The *back* of the nose is formed by the junction of the nasal bones above, and of the lateral cartilages below: it is upon the development of these bones that the form of the organ is chiefly dependent.* The *Alæ* or *wings* constitute the lateral boundaries of the nostrils, and are prolonged into the *lobe* or extremity of the nose. These alar cartilages are two in number on each side, the superior being triangular and flattened, the inferior curved and convex externally. The *Septum* of the nose is formed by a fifth cartilage, which is triangular and flat, and continuous with the bony plate which divides the nostrils behind. It meets the alar cartilages below in the lobe, and is here covered by a thick fold of the common integument called the *Columna*, which connects the tip of the nose to the upper lip. The lobe and columna are moulded on a separate pair of cartilages.

The *Nostrils* are a pair, oval in form, and bounded by the septum and columna internally, and by the alar cartilages externally. Their inner surface is furnished with strong hairs, which are of use to arrest the introduction of extraneous bodies during the act of inspiration. The *Nasal Cavity* presents an extended surface covered throughout by mucous membrane, and is in communication with several *Sinuses* which are likewise invested by productions of the same continuous membrane. The bones which constitute the nasal cavity are fourteen in number, of which four are single bones and five are pairs. A central partition divides this cavity into two portions: this septum is vertical and continuous with the anterior cartilaginous septum of the nostrils already alluded to. It consists of the vomer, joining before with the nasal plate of the ethmoid bone, below with the palate and superior maxillary bones, and above with the sphenoid. The lateral boundaries consist of the superior maxillary, palate, sphenoid, ethmoid, turbinated, and lachrymal bones; the roof being formed by the frontal, ethmoid, and sphenoid bones, and the floor by the palate and superior maxillary bones. Lastly, the circumference of the common posterior aperture is formed by the sphenoid and palate bones: this outlet communicates, in

* For the description of these and other bones to which it will be necessary to allude, the reader is referred to the 'Osseous System.'





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Anatomy. the recent state, with the pharynx. The projection of the convoluted plate of the turbinated and ethmoid bones from the external walls of the nasal cavity, subdivides each lateral half into three compartments or chambers; into the superior of these the posterior ethmoidal and sphenoidal sinuses open. The middle chamber presents the apertures of communication with the frontal anterior ethmoidal and maxillary sinuses; and the inferior receives the nasal duct.*

It has been already remarked that there is a continuous mucous membrane common to the nasal cavity and sinuses; this is denominated the *pituitary* or *Schneiderian* membrane. It is extended over the periosteum of the bony parietes, and covers the nasal surface of the cartilages and septum, being continuous anteriorly with the common integument, and posteriorly with the mucous membrane of the pharynx and larynx. It further sends a production into each sinus, and in the nasal duct becomes identified with the conjunctival membrane of the eye. The pituitary membrane is thicker and more villous in character on the turbinated bones and septum; but in the sinuses it is comparatively pale and thin. Its surface is continually lubricated by *mucus*, which is poured from the orifices of numberless minute follicles, by which means the delicate surface is protected and the function of the organ is rendered more perfect. The *muscles* which move the nose, or its tegumentary covering, are the following:—The *pyramidalis*, which is vertical in its course, and raises the skin covering the nasal bones. The *compressor nasi* covers the ala, and unites with its fellow on the back or bridge of the nose, its use being to compress the corresponding ala. The *levator labii superioris alæque nasi* is partly inserted into the side of the ala cartilage, and thus is enabled to distend or elevate the nostril. The corresponding *Depressor* is its antagonist.† *Arteries.*—The principal internal artery of the nasal cavity is the spheno-palatine branch of the internal maxillary. This enters by the foramen of that name, and immediately divides into branches which ramify beneath the mucous membrane upon the septum and turbinated bones, also sending twigs to the ethmoidal cells and antrum. The superior palatine artery also sends a small branch through the anterior palatine foramen to the nasal fossa, and the antrum is likewise supplied from the upper alveolar artery. The posterior ethmoidal branch of the ophthalmic sends some twigs down through the cribriform plate of the ethmoid bone to the pituitary membrane, and the internal carotid itself supplies the sphenoidal sinus. The facial supra and infra-orbital branches supply the cutaneous surface of the nose. The *Veins* pursue nearly the same course as the arteries; one of them sometimes communicates directly with the anterior extremity of the longitudinal sinus of the skull. *Nerves.*—The nasal cavity is supplied by nerves of specific and common sensibility: the former are the olfactory, the latter are derived from the fifth pair. The olfactory nerves (a pair) divide on either side of the crest of the ethmoid bone into numerous branches, and assuming a firm consistence descend through the foramina in its cribriform plate. They carry with them investing sheaths of dura mater, and are distributed *externally* on the turbinated bones, and *internally* on the septum nasi, ramifying between the periosteum and pituitary membrane, in the latter of which they terminate. The sensitive nerve of the nose is the nasal branch of the ophthalmic division of the fifth pair. After traversing the orbit, this nerve enters the skull by the anterior of the internal orbitar foramina, and almost immediately descends through the cribriform plate of the ethmoid bone into the nasal fossa. It is distributed to the lining membrane and skin of the nostril, and to the mucous membrane of the nasal chambers. In addition to the foregoing, the nose receives filaments from the spheno-palatine ganglion of the sympathetic system. One of these is derived from the palatine nerve, and passes through a foramen in the nasal plate of the palate-bone, to terminate in the mucous membrane between the turbinated bones. Several smaller filaments pass from the above ganglion through the spheno-palatine foramen, and are distributed in common with the last.

*Physiology.*—From what has been said respecting the nervous organization of the sense of smell, it will be perceived that this organ is endowed with a specific sensibility by which various odours are distinguished; and with common sensibility, by which the intrusion of foreign particles during respiration is arrested. There appears little reason to doubt that all the sources of stimulus are material, whether in a solid, fluid, or gaseous form. Thus, both the nerves of common and specific sensibility may be simultaneously excited by fine powders, conveyed by the atmosphere to the sensitive surface. It appears essential, however, that whatever may be the stimulus, it should be ultimately dissolved or suspended in the mucus, which thus becomes its real menstruum when applied to the sentient extremities of the nerves. Thus the morbid condition in this secretion in catarrh impairs, or totally suspends for a time, the specific function of the organ. Scents are naturally conveyed to the organ of smell at each inspiration, and thus we are in part made aware of the presence of matter which may be noxious to the lungs. By voluntary inspiratory efforts, a current of air is thrown at pleasure upon the mucous surface, by which means an odour is rendered more or less intense; thus animals, in following their prey, "snuff" the air on the ground, the act consisting of short and frequently repeated inspirations. Although this sense is infinitely more acute, under certain circumstances, in animals than in man, it is probably much more limited in its range. The specific stimulus varies according to the habits and wants of animals, whereas in man the extension and uniformity of its sphere renders the sense of smell a source of enjoyment, as well as of usefulness; for we cannot reasonably doubt that the sweet scents, which are so abundantly diffused throughout the vegetable kingdom, are unappreciated by animals, as they possess no attraction save where they act as a guide in the selection of food. An illustration of this point is found in the fact that odours affect different individuals in various ways, some regarding as agreeable what others are disgusted with; and again, certain scents, particularly of flowers, are not perceptible to some persons, but are overpowering to others. This sense is occasionally impaired, or totally lost for a time (sometimes permanently), after severe concussion or other affections of the brain.

ORGAN OF TASTE.—The *Tongue*, which is the seat of

* As it seems doubtful whether these sinuses are in any way subservient to the sense of smell (at any rate in man), no further notice will be here taken of them.

† For further particulars, see 'Muscular System,' pp. 410-11.



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this sense, is a highly endowed muscular organ, consisting of two lateral portions, which are symmetrical. Its form is triangular, being broad at its base, where it is connected posteriorly by a continuous mucous membrane to the palate and epiglottis, and inferiorly by several pairs of muscles to the os hyoides and lower jaw. Its anterior extremity is pointed and free. The body of the tongue presents a superior surface, which is slightly rounded and marked by a central longitudinal groove when in a state of rest: it may be rendered concave or convex. The under surface is convex, and attached by a central fold of mucous membrane (*frænum linguæ*) to the neighbouring parietes of the mouth. The margins are rounded, and connected at their posterior extremities by the anterior pillars of the fauces to the arch of the palate. The mass of the tongue is made up of the *muscles* which move it. They consist of the following pairs:—The Stylo-glossus, which draws the tongue backwards and to one side; the Hyo-glossus, which depresses the side of the tongue, and thus renders its back convex; the Genio-hyo-glossus, the extent and position of which render it the most important agent in the motions of the tongue. Its mesial insertion enables it to render this organ concave; its posterior fibres draw the base of the tongue forwards, and thus thrust the point from the mouth, whilst its anterior retract the apex, and cause it to point downwards. The lingualis consists of a longitudinal fasciculus of fibres, which traverse the tongue external to the last described, from its apex to its base: they shorten the organ and retract its tip. Several other muscles connected with the os hyoides and lower jaw act indirectly on the tongue. It should be remarked, that an unusual quantity of fatty matter is found intimately mixed with the muscular structure of this organ.* The *Mucous membrane* of the tongue is continuous with that of the mouth generally. It is not characterized by any peculiarity on the under surface of the organ, but on the upper surface it is rendered uneven by the prominence of papillæ and the large mucous follicles, which are distributed unequally over it. These papillæ are divided into lenticular, fungiform, and conical, names derived from their varied form. The first are large follicles with open mouths, arranged in two rows, which are separated anteriorly, and converge to an angle posteriorly, where the largest and deepest (*foramen cæcum*) is seen. The fungiform and conical papillæ are distributed severally over the edges and dorsal surface of the tongue, presenting the appearances which their names denote.

The *Arteries* of the tongue are the lingual branches of the external Carotid; they arise nearly opposite the corner of the Os hyoides, and take a tortuous course forwards, upwards, and inwards towards the base of the tongue, and then insinuating themselves between the hyo and genio-hyo-glossi muscles of either side, they run forwards towards the tip, where they terminate; they distribute branches in their course, which are severally named, according to their destination, dorsal, sublingual, and ranine. The *Veins* accompany the arteries. The *Nerves* of the tongue are three pairs: the lingual branch of the fifth, the glosso-pharyngeal of the eighth, and the hypo-glossal or lingual motor. After separating from the dental nerve, the lingual branch of the fifth is found lying between the internal lateral ligament of the lower jaw and the internal pterygoid muscle; thence it passes between the upper margin of the sub-maxillary gland and mucous membrane of the mouth, and here joins the Whartonian duct, which it accompanies between the mylo-hyoid and hyo-glossus muscles; it lastly crosses above the sub-lingual gland, to divide into its terminating filaments on the outer surface of the genio-hyo-glossus muscle. After giving off branches, which are distributed to the various textures along which it passes, viz., the muscles, glands, and mucous membrane of the mouth, gums, and pharynx, it communicates freely with the lingual motor nerve, and its ultimate filaments are distributed to the mucous membrane of the whole upper surface of the tongue as far as its tip. The Glosso-pharyngeal nerve escapes from the skull by the posterior lacerated foramen, and almost immediately crossing from the anterior to the inner side of the internal Jugular vein, it proceeds in company with the Stylo-pharyngeus muscle, between the external and internal Carotid arteries, to the base of the tongue; here it terminates, by distributing its filaments to the mucous membrane in this region, and to that of the epiglottis, tonsils, and upper part of the pharynx. Lastly, the ninth or lingual motor nerve leaves the skull by the anterior condyloid foramen, and taking a course downwards and forwards it hooks round the occipital artery and passes external to the par vagum, superior cervical ganglion, and both external and internal carotid arteries. It next appears from under cover of the digastric muscle, and forms a loop with its convexity downwards, prior to its disappearance between the mylo-hyoid and hyo-glossus muscles. After giving off its long descending branch, which is distributed to the muscles which depress the larynx, it gives off filaments to the following muscles: the mylo-hyoid, genio-hyoid, thyro-hyoid, stylo-pharyngeus, constrictor pharyngis superior, and those already enumerated as specially acting on the tongue. After quitting the hyo-glossus (which muscle is interposed between the corresponding artery and nerve), it runs forwards in company with the lingual vessels between the genio-hyo-glossus and lingualis muscles to the tip of the tongue, where its ultimate filaments terminate by being exclusively distributed to muscles. It communicates freely with the lingual branch of the fifth.

*Physiology.*—The senses of smell and taste are closely allied, the impression being direct in either instance. It would appear that the sense of taste does not reside wholly and exclusively in the tongue; the fauces partake of the endowment. The stimulus may be presented, as in the sense of smell, in a solid, fluid, or gaseous form; and the conditions of the organ for specific perception are likewise similar, viz., a moistened surface, and solution or suspension of the excitant, if a solid. The true nervous seat of taste has been a subject of dispute amongst physiologists, and the recounted experiments are very contradictory. No doubt, however, exists that the hypo-glossal is the motor nerve of the tongue, though it does not appear to be totally devoid of sensibility, which is probably attributable to the interchange of fibrils between it and the fifth. The weight of evidence is in favour of this latter being the gustatory nerve, though we have certain evidence that it also presides over common sensibility. The most probable function of the Glosso-pharyngeal nerve

* For further particulars, see 'Muscular System,' p. 413.

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 is to combine the actions of the tongue and pharynx in deglutition. The senses of taste and smell often co-operate for the production of a more perfect result; thus, wines cannot be so accurately appreciated, nor indeed any delicate flavour, when the nostrils are closed. Taste also is affected, as smell, in catarrh, probably rather from the cause above alluded to than from direct local affection. We know nothing respecting the mode by which we are enabled to distinguish between different tastes and scents. The tip of the tongue is highly endowed as an organ of common sensation, which property it derives from the lingual branch of the fifth nerve. In addition to the above functions, the tongue is a most important agent in the acts of mastication, deglutition, and articulation.

Sense of Touch.—The organ of this sense is not limited to any particular locality, though the intensity of the sense itself varies much in different parts. The nervous filaments of common sensation may be traced back to the posterior roots of the spinal nerves, which have their origin in the brain—a fact demonstrated by the loss of sensation when the communication with this nervous centre is cut off. By far the largest proportion of these filaments terminate in the true skin, which is protected by an unorganized covering, the cuticle.* The generally diffused sense is usually termed "common sensation;" whilst the more highly endowed parts, as the fingers and tongue, constitute the "appropriate sense," by which greater nicety of distinction is possessed. Pleasure, pain, heat, cold, &c., are modifications in excess, or otherwise, of common sensation. The acuteness of the sense appears to depend on the proportion of nervous matter distributed to a given space. It seems probable that some individuals possess more acute sensibility than others; and it is to be hoped that most animals are less gifted in this respect than man. The sexual pleasure appears to be a refinement of the form of common sensation above alluded to, rather than an appropriate sensibility *sui generis*, its peculiarity consisting in the crisis of the orgasm producing the excited effect of seminal emission. But this is only the result of an adaptation of appropriate structures and functions to each other for the attainment of a desired end; for the peculiar property of the pudic nerve soon ceases when the chain is broken by the removal of an essential link, such as the secreting organs of the generating fluid. The endowed structure in the production of the act of generation is that part in which the ultimate filaments of the pudic nerve are distributed, whether that structure be perfect or mutilated; and thus in this instance, as in the *Senses*, it is the peripheral extremities of the nerve, and not the *organ*, which are the real seat of the emotion.

The *causes* of sensation are various, viz., mechanical, chemical, electrical, &c.; the first mentioned are by far the most frequent. The fingers and tongue are the parts most highly endowed in man; whereas the lips are specially the seat of the sense in some animals, as the horse; the extremity of the proboscis in the elephant, &c. Many parts not naturally sensible become so under inflammation, as tendon, cartilage, and probably horn and teeth. The great centre of all sensation, the Brain, is insensible. How sensation is conveyed to the sensorium we know not; it may be  by pulses or undulations, of which the nerves are the conductors. Pain may result from violence, the effect being purely mechanical; but where heat or external cold are the causes, it is probable that there is a chemical change in the organized tissue. The amount of sensation in these cases bears a direct proportion to the conducting power of the body touched. Habit improves and perfects our appreciation of the form, surface, &c., of objects in the same way as the eye requires experience to calculate distance. The greatest perfection of the organ of touch is exemplified in the congenitally blind, who employ the sense vicariously. Such individuals are taught to read by raised letters, and instances have been authenticated where various colours have been distinguished; but this may be accounted for by some appreciable difference produced in the texture of the cloth by the dye employed to colour it, and has nothing in common with the marvellous tales of the Mesmerists. The hand is highly endowed in man, and peculiarly fitted for the office of an organ of touch by its form and mobility. It is by the adaptation of the thumb and fingers that we are enabled to appreciate dimensions; and by the pronation and supination of the fore arm we judge of form and surface. Lastly, it may be noticed that some sensations have their origin in internal or central causes.

Organ of Hearing.—The mechanism of the internal Ear, which constitutes the modifying apparatus of this organ, is very complex. The *Labyrinth* is the part endowed with the sense of hearing; i. e., it presents a surface on which the ultimate filaments of the auditory nerve are distributed. It is partly osseous, and in part membranous, and is divided into three compartments; 1. Vestibule; 2. Semicircular canals; 3. Cochlea. The *Vestibule* is placed to the inner side of the tympanum, having the cochlea anterior and inferior to it, and the semicircular canals above and behind it. Its diameter is one-fifth of an inch by one-tenth laterally, and it presents the following openings; foramen ovale, by which it communicates with the tympanum; five orifices of the semicircular canals; cochlear foramen; its own aqueduct, and several minute orifices by which the filaments of the auditory are admitted. The Semicircular canals are three in number, and situated behind the tympanum. Their calibre is about one-twentieth of an inch, and they are somewhat compressed laterally; two are vertical in position, and the interior of the three is horizontal: of the two vertical the anterior is also superior. The inner extremity of the anterior, and the upper extremity of the posterior, vertical canals unite; hence five instead of six openings into the Vestibule. The *Cochlea* is internal to the Vestibule; it is a coiled tube about an inch and a half long, tapering and forming two and a half curves, the greatest diameter being about one-tenth of an inch at its commencement. This tube is called the *spiral canal*, and its commencement projects towards the tympanum, and forms the *promontory* within that cavity. The *cul-de-sac* at the sommit is termed the *cupola*; and the central pillar or *modiolus* is perforated by a middle tube, which presents foramina communicating with either scala for the transmission of nervous filaments. There are two *scalæ* divided by a partition (*lamina spiralis*), which terminates in the *hamulus*, where a communication exists between the two scalæ. The *scala tympani*, which is the lower of

* The reader is referred back to the anatomy of these structures.



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the two, communicates with the tympanum by the fenestra rotunda; and the *scala vestibuli* with the vestibule by an oval opening. The aqueduct, which is about a quarter of an inch long, commences at the lower wall of the tympanic scale, and terminates in the jugular pit of the petrous bone. The labyrinthic cavity is lined by a fibro-serous membrane in addition to the proper membrane of the labyrinth. In each compartment of this cavity a fluid is found called the *peri-lymph* or *liquor Cotunnii*. The *membranous labyrinth* is found in the vestibule and semicircular canals only; it floats in the peri-lymph except where connected to the sides of the osseous labyrinth by mucous filaments; the cavity of this membrane contains a limpid secretion, and some particles of calcareous matter. The *accessory* apparatus of the organ of hearing consists of the Auricle, Auditory passage, and Tympanum. The *Tympanum* is interposed between the auditory passage and labyrinth; its greatest diameter is nearly a quarter of an inch. It is lined by mucous membrane, and shut off from the auditory passage by the *Membrana tympani*, which faces backwards, upwards, and outwards, and consists of a double layer of fibrous membrane, lined internally by the membrane of the tympanum, and externally by cuticle. On the inner wall of the tympanum the promontory is seen, above which is the oval or vestibular fenestra, and below it the cochlear or round fenestra. Superior to the former of these is a ridge marking the course of the aqueduct of Fallopius; whilst below and behind it is the pyramid, with an aperture on the summit for the lodgment of the Stapedius muscle, and passage of its tendon. Still further back is the orifice for the entrance of the chorda tympani nerve. In addition to the above openings, there are the following:—On the fore and upper part of the cavity the *Glenoid foramen*; at the lower part the orifice of the *Eustachian canal* and tube for the lodgment of the *tensor tympani* muscle, which two last are separated by a scale of bone; and posteriorly the communications with the mastoid cells. The *osseous* part of the *Auditory passage* is nearly three-quarters of an inch in length, passing from without inwards and forwards, at first being inclined upwards and then downwards; its centre is most contracted. Its outer margin is rough to give attachment to the auricular cartilage; and a groove just within the inner extremity marks the attachment of the membrana tympani. In the fœtus this passage is a mere bony ring, which, attaching itself to the outer wall of the tympanum, subsequently grows into the osseous passage above described. The *Mastoid Cells* are irregular in number and size, and occupy the mastoid portion of the temporal bone; they do not exist in the young. The *Ossicula Auditus* are four in number. The *Malleus* is divided into a rounded head and three processes, of which two are long and the third a mere tubercle; the handle, as the largest process is named, rests on the membrana tympani, and the processus Gracilis projects into the Glasserian fissure. The *Incus* is like a double-fanged tooth, presenting an expanded summit which articulates with the head of the malleus; and two legs, of which the longer is connected through the medium of the *lenticular* bone to the Stapes. The former of these two last named is like a flattened grain of sand; the latter or *Stapes* resembles a stirrup, the base of which is adapted to the vestibular foramen. These bones are contained in the cavity of the tympanum, and stretch from the membrana tympani to the membrane of the vestibular openings. The *Auricle* is placed on the side of the head, and consists of fibro-cartilage invested by common integument. The hollowed portion of the *pinna* is called *concha*; its convex outline is the helix, below which is the *antihelix*; this latter divides above, and the intervening depression is called *fossa navicularis*. Bounding the external meatus anteriorly is the tragus, opposite to which is another elevation called anti-tragus; the most depending part of the auricle is the *lobe*. The external or *cartilaginous auditory passage* joins the osseous canal already described, their joint length somewhat exceeding an inch, and extending from the bottom of the concha to the membrana tympani: this canal is curved, and its concavity faces downwards and forwards; its transverse section presents an ellipse. The skin lining this passage is furnished with fine hairs, and the *ceruminous glands* pour out a bitter secretion from numerous orifices.



*The Muscles* of the internal ear are two: the the tensor tympani, which lies in a canal above the Eustachian tube, from which, and the adjoining portion of the petrous bone, it arises; on entering the tympanum it bends towards the malleus, into which it is inserted at the junction of the handle and processus gracilis: it makes tense the tympanic membrane. The Stapedius is lodged in the pyramid, from the summit of which it emerges to be inserted into the neck of the stapes: it presses the base of the stapes against the fenestra ovalis, and probably co-operates with the last muscle by drawing the chain of bones inwards. A third muscle is described by some authors, and named laxator tympani, but it appears rather of a ligamentous character. The muscles moving the external ear are the attollens, attrahens, and retrahens aurem, which severally arise in the temporal, zygomatic, and mastoid regions, and act in the directions denoted by their names. Others have been described, which are so rudimentary as to be undeserving of notice.

The *Arteries* which supply the internal ear consist of twigs derived from the internal Carotid and Basilar trunks, and also from those of the dura mater and the posterior aural; the last of which enters by the stylo-mastoid foramen. The external ear is furnished by the continued trunk of the last-named artery, and by twigs from the temporal. The *Veins* correspond to the arteries.

*Nerves.*—The Auditory nerve enters the internal passage of that name in company with the facial: the former divides at the bottom of this canal into two branches, the anterior or *cochlear*, and the posterior or *vestibular*. The former, flattened, enters by several filaments the apertures of the spiral tract of holes; these pass into the bony spiral lamina, where they spread out in curves: the filaments entering the base of the axis emerge at the summit of the cupola. The vestibular branch presents a gangliform enlargement which divides into three sets of filaments, two for the canals and one for the vestibule. The muscular nerves of the internal ear are derived from the facial and the otic ganglion. It should be observed that the tympanic orifice of the Eustachian tube communicates by an expanded cartilaginous aperture (looking downwards and backwards) with the side of the pharynx, opposite the posterior openings of the nasal cavity.

*Physiology*—The organ of Hearing justly occupies an elevated position among the senses; the privation of it can alone convey an adequate notion of its im-

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portance, especially where the effect is congenital. Yet is it not only an useful sense; through it some of our tenderest sympathies are awakened, or the depressing effects of the sterner passions assuaged; and thus the adaptation of the organ to the music of nature or art becomes a source of the highest gratification to most persons. *Sound* is any impulse of the air conveyed to our ears, and the body which originates the vibration has been denominated the "Phonic." These airy waves or impulses move like circles produced in water when disturbed by a falling body, and must succeed each other with a rapidity amounting to at least sixteen in the second to produce a continuous sound. The Vestibule is the principal seat of the expansion of the auditory nerve, and communicates, as has been shown, directly with the tympanic chain of bones; it is also that part of the internal ear which is most universally developed, and therefore is probably the most essential part of the labyrinth. The Cochlea is found in more advanced development, and probably receives impressions conveyed through the cranial bones; its peculiar form is a mystery. The semicircular canals have been supposed to subserve the end of detecting the direction of sound: it is certain they present an extended surface for the expansion of the auditory nerve. The External Ear is more developed in many animals than in man: in these instances the size, erect position, and mobility of these organs permit of a more ready detection of the direction of sound. The obliquity of the external auditory passage is a protection against injury to the membrane of the drum and parts within. The tympanum, membrane, and ossicles render the labyrinth independent of atmospheric vicissitudes, and protect it against violence from intensity of atmospheric vibrations. The muscle of the malleus acts directly on the tympanic membrane; that of the stapes mediately on the same part, but more directly on the membrane of the vestibular foramen. The tension of the membrane of the drum renders it more susceptible of vibration, and consequently permits of the appreciation of gentle sounds; but extreme tension prevents the perception of grave tones. The use of the Eustachian tube is to admit air into the tympanum: it may also subserve other purposes, such as the escape of vibrations which might otherwise produce an echo. This last property may likewise be assigned to the mastoid cells, which are doubtless also intended to improve the conducting power of the solid bones.

*Organ of Vision.*—Under this head will be considered the Orbit, the Globe of the eye, and its appendages. The *Orbits* are conical cavities facing forwards and slightly outwards; their axis is therefore oblique. Each is formed above by the frontal bone; below by the superior maxillary and malar bones; externally by the last named and the sphenoid; internally by the lachrymal, ethmoid, and palate bones: thus, three single bones and four pairs enter into the composition of this cavity. The margin of the orbits is strong and rounded, and well calculated to sustain and ward off external violence. The weakest part of the cavity is its inner wall, and its external is the strongest. The orbitar foramina are,—the optic at the posterior and most contracted part of the cavity; the lacerated external and inferior to the last; the supra-orbitar and frontal in the os frontis; the anterior and posterior ethmoidal between the bone of that name and the frontal: the intra-orbitar canal is also partially open to the orbit, and the spheno-maxillary fissure communicates between this cavity and the spheno-maxillary fossa. The *Globe* of the eye occupies the orbitar cavity, cushioned on a bed of fat, and more or less prominently placed in different individuals and under varying conditions of the frame.* The form of the globe is that of a spheroid, the greatest diameter of which is about an inch, and extending from before backwards. The axis of the two eyes is parallel, and therefore not corresponding to that of the containing cavity. The bulk of the eye consists of the humors, which are more or less supported and surrounded by the membranes.

The *Sclerotic* coat is a fibrous tissue, dense, tough, and white, and investing about four-fifths of the globe. It is thickest where it is perforated for the transit of the optic nerve, and gradually decreases to one-third of its density where it is connected to the cornea; this more attenuated portion is, however, strengthened by the expanded insertions of the muscles which move the globe. Posteriorly this membrane is continuous with the dura mater accompanying the nerve of sight through the optic foramen: its external surface is in part covered by the investing conjunctiva, and internally it is in contact with the choroid membrane. The aperture for the optic nerve is in its posterior aspect, and about one line internal to its centre. The *Cornea* occupies the anterior fifth of the globe, being connected by its margin to the sclerotic. Its transverse rather exceeds its vertical diameter, and it forms the segment of a smaller sphere than the opaque membrane into which it is inserted. The border of the transparent cornea is overlapped, at their junction, by the sclerotic. The texture of the former differs essentially from that of the latter, consisting of laminæ with an interposed transparent fluid. Anteriorly the Cornea is covered by a transparent secreting membrane, and posteriorly by the membrane of the aqueous humor.

The *Choroid* membrane corresponds to the Sclerotic externally, and to the retina within. It is perforated posteriorly by the optic nerve, and anteriorly it is adherent to the Ciliary ligament and processes. This membrane is of a deep brown tint, an appearance which is due to the colouring matter or pigment with which it is stained. It is cellular and highly vascular, its external surface being rough where its connexions with the Sclerotic are broken through, and its internal surface villous where the terminations of the vessels are spread out. The secreting apparatus of the pigment appears to consist of a series of hexagonal plates, with a central nucleus on the inner surface of the choroid. This colouring matter is absent in albinos. The *Ciliary ligament* is an annular band of condensed cellular texture and grey colour, corresponding to the junction of the sclerotic with the cornea, and of the choroid with the iris, and serving as a connecting band between these several tissues. It is perforated by the ciliary vessels and nerves. The *Ciliary processes* are a set of folds continued forwards from the choroid behind the iris. They are highly vascular, and stained with pigment; they are alternately long and short, and about sixty or seventy in number. The hyaloid membrane is marked by their attachment, but their extent is limited anteriorly by the margin of the lens. The *Iris* is a septum placed vertically between the cornea and lens, the convex border of which is attached,

* The sunken eye of the emaciated depends on the absorption of the fatty cushion alluded to.

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through the medium of the ciliary ligament, to the choroid membrane; and the concave, or free margin, forms the boundary of the *Pupil*. This aperture is not quite central, but a little inclined to the inner side of the transverse diameter of the eye. It is upon the tint of the iris that the colour of the eye depends. Its posterior surface is stained by pigment, which is more abundant and pervades its structure in dark eyes, but is altogether absent in albinos. The texture seems to be, in part at least, muscular, and to consist of both radiating and circular fibres, of which the former are anterior. It may be remarked that the iris divides the interval between the cornea and lens into two unequal *Chambers*, of which the posterior is much the shallower. The surface of this septum is covered by the membrane of the aqueous humor, and floats in the liquid. During fœtal life a vascular membrane, denominated *Membrana pupillaris*, closes the pupillary aperture; this gradually disappears towards the close of uterine existence. The *Retina* is the expanded termination of the optic nerve, and is, consequently, the true seat of vision. This membrane is interposed between the choroid and the vitreous humor, and extends as far forwards as the posterior margin of the ciliary processes. It is constituted of three layers, the central of which is nervous, the anterior vascular, and the posterior or external serous These laminæ are connected by vessels and cellular tissue, the nervous expansion thence deriving the support it needs. This membrane, which exhibits an opaque grey appearance on dissection, is perfectly transparent during life. It presents on its inner surface and in its centre, but about two lines external to the optic nerve, a spot where the nervous matter is deficient, and around which the membrane is folded and has a yellow tint; this is denominated the *foramen of Sömmerring*. The central artery of the retina may be seen emerging on its inner surface from the centre of the optic nerve.

The *Vitreous humor* constitutes about three-fourths of the contents of the eye-ball. It is spherical, and presents a depression on its anterior aspect in which the crystalline lens is lodged. The fluid of which its bulk consists is slightly saline, and contained in a cellular membrane called *Hyaloid*, which not only surrounds it exterior, but also forms cells in its interior. The connexions between the hyaloid membrane and choroid folds are very slight; the relation of the retina to the former has been already noticed. At the margin of the lens the hyaloid membrane splits, to invest on both surfaces the crystalline lens By this arrangement a cellular canal is formed, which surrounds the circumference of the lens, and named after its discoverer, Petit. It should be observed that this canal can only be developed by inflation. The dark markings on the hyaloid membrane, corresponding to the intervals on the plaits of the choroid or ciliary processes, appear themselves to be similarly constituted folds, and are thence named the ciliary body of the vitreous humor. The *Crystalline humor* is a double convex lens, related, as already described, to the membrane of the vitreous humor, and lying behind the iris, where it forms the posterior boundary of the smaller chamber of the eye. Its position corresponds to the axis of the pupil, and its posterior surface is more curved than its anterior. The antero-posterior diameter of the lens is about two lines, which is half of its transverse measurement. The convexity of this body, however, varies at different periods of life, the curves being greater in childhood, when the lens is nearly spherical, and diminishing rapidly after middle age. The crystalline lens is invested by a capsule, which contains a small quantity of transparent fluid called *Liquor Morgagni*, and supposed by some to be a *post-mortem* condition; this capsule is tough and elastic The humor under consideration is far from homogeneous; it consists of radiating fibres, the arrangement of which is very complex, and varies in different classes of animals. Mention has been already made of a large chamber in the eye, situated between the cornea and lens, and divided into two unequal compartments by the floating margin of the iris, which is very nearly in contact with the crystalline humor. This space is occupied by the *Aqueous humor*, a limpid transparent fluid of about five grains' weight. This liquid is supposed to be the product of a membrane which covers the boundaries of the chambers and the surfaces of their floating septum, and thence called aqueous membrane—a fact which has not been anatomically established, although the pathological evidence presented to us would seem to favour the hypothesis.

Under the head of *Appendages*, the following parts will present themselves for examination:—The eye-brows, eye-lids, conjunctiva, and lachrymal apparatus. The *Eye-brows* consist of two arched lines of hairs directed outwards and downwards, and approaching, or even sometimes meeting, in the median line. The integument which supports these strong hairs is thick, and lies over the frontal ridge. The brows are raised by the action of the occipito-frontales muscles, and corrogated or knit by the corrugatores supercilii. The *Eye-lids* are superior and inferior, of which the former is considerably the deeper. They are united by an inner and outer *commissure*, and the intervening aperture varies according to the separation of their margins. Their texture is constituted of muscle, fibro-cartilage, and common integument. The *Tarsal fibro-cartilages* support the eye-lids, and give form and thickness to their margins. The superior is much deeper than the inferior, and the border of each is thick, and corresponds to the curve of the globe. On their margins the conjunctive membrane terminates, and the orifices of the *Meibomian follicles* are seen. These glandular sacs are in linear arrangement on the borders of the tarsal cartilages; and external to them are the eye-lashes, *Ciliæ*, consisting usually of three rows, and longer and more numerous in the upper than the lower lid: they are curved, with their convexities towards each other. The Skin of the eye-lids is very delicate, and quite destitute of adipose tissue. The *Conjunctiva* is a reflected secreting membrane, more nearly allied to the mucous than any other class of membrane. It covers the internal surface of the palpebræ, and is reflected from them upon the sclerotic coat of the eye, to which it adheres. It cannot be raised beyond the margin of the cornea, whence it has been supposed by some anatomists that it is absent on this structure, an opinion which is scarcely substantiated by pathology. This membrane is continuous with that of the nasal fossæ, through the communicating ducts. A fold of the conjunctiva, named the *Caruncle*, occupies the inner angle of the eye; and another, of a semilunar form and indistinct, may be observed on the inner part of the globe. The *Lachrymal apparatus* consists of the gland, puncta, sac, and duct. The *Lachrymal*

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*Gland* occupies the deep hollow of the upper and outer part of the orbit, behind the conjunctiva. It is of a greyish brown colour, composed of granules, and convex towards the orbit, but flattened on its ocular aspect. Its secretion is poured out by five or six small ducts, which open on the surface of the conjunctiva, where this membrane is reflected from the upper lid to the globe. The *Puncta lachrymalia* are the orifices of the ducts of the same name. They are placed opposite each other on an eminence of either tarsal cartilage, about two lines distant from the inner canthus; and they communicate with a small channel, which is formed between the above cartilages and the eye-ball when the lids are closed. Of the lachrymal *ducts* the superior is the longer and more curved, the inferior being short and nearly horizontal. They open into the *Lachrymal Sac*, which occupies a space formed for it at the union of the upper jaw and lachrymal bones. It is an oval membranous bag, which contracts below to communicate with the nose by the *Nasal duct*. The canal which lodges this duct is completed, in addition to the two bones first mentioned, by the os turbinatum. The duct itself is about three-quarters of an inch in length, and in its descent it inclines a little backwards and outwards. Its nasal orifice is oblique and valvular.

The *Muscles* of the eye-ball are four straight and two oblique. The *Recti* all arise around the optic foramen, the external likewise contracting an origin from the lacerated foramen of the orbit; they are severally named, according to their action, abductor, adductor, levator, and depressor oculi. The *Superior Oblique* muscle rolls the eye so as to direct the cornea downwards and outwards. The *Inferior Oblique* rotates the eye upwards and outwards. The two oblique muscles also antagonize the straight by drawing the eye-ball forwards. The muscles of the lids are, the *Levator Palpebræ Superioris*, which arises in common with the recti, and expands on the upper lid; and the *Orbicularis Palpebrarum*, which consists of a pale expanded fasciculus of fibres surrounding the eye, and spread beneath the skin of the eye-lids and that covering the adjoining part of the brow and cheek; its only fixed attachment is to the nasal processes of the frontal and superior maxillary bones, and to a small tendon (*Tendo Oculi*), which is connected to the latter bone and inner commissure of the tarsal cartilages, crossing in front of the lachrymal sac. This muscle closes the lids, directs the tears to the puncta, or expresses them on to the cheek. Other muscles of the forehead and face act on the integuments surrounding the orbit.*

*Arteries.*—The internal Carotid artery gives off a branch, which is destined especially for the supply of the eye. The *Ophthalmic* artery arises from the above-named trunk as it is placed beneath the anterior clinoid process of the Sphenoid bone. It enters the orbit by the Optic hole, at first lying external, and then superior to the nerve; it then proceeds obliquely forwards and inwards to the inner side of the orbit, crossing beneath the Levator palpebræ and oculi, and subsequently parallel to the Obliquus superior. While external to the Optic nerve it gives off a large branch, the *lachrymal*, which takes its course outwards to the lachrymal gland; this structure it supplies, and likewise the upper eye-lid. A small but important branch is also separated from the Ophthalmic artery in the above position, viz., the *Central* artery of the *Retina*: this penetrates the substance of the Optic nerve, and traverses its centre, emerging on the inner surface of the retina, the vascular coat of which it assists in forming; a twig from it pierces the vitreous humor and supplies the capsule of the lens. The *Supra-orbitar* branch is next detached, with the ciliary and muscular branches, when the artery is above the Optic nerve. The first of these runs forward close to the roof of the orbit to the supra-orbitar foramen, where it emerges, to terminate in the muscles and skin of the frontal region; in its course it aids in the supply of the ocular muscles. The *Ciliary* arteries are short and long: the former are very numerous, and surround the Optic nerve as they pass forwards to pierce the sclerotic; they subsequently traverse the choroid and ciliary circle, supplying each structure in their progress, and terminate in the iris. The long ciliary branches, which are two in number, take a similar course, one on either side of the Optic nerve, and likewise terminate in the iris. The arterial circles of the iris are formed by the above vessels. The *Muscular* branches supply the various muscles. The *Ethmoidal* branches leave the orbit by the internal orbitar foramina, and supply the ethmoidal cells, frontal sinus, and nasal fossa. The two *Palpebral* branches supply either eye-lid and the neighbouring lachrymal apparatus. The Frontal branch leaves the orbit near the notch for the oblique pulley, and supplies the muscles and skin of the fore head. The *Nasal* is the terminal branch; it accompanies the last named on to the forehead, and then passes inwards to the nose, where it anastomoses with the ultimate branch of the facial. The four last described leave the Ophthalmic artery whilst it is internal to the Optic nerve. In addition to the above main source, the appendages of the eye receive branches of supply from the facial, infra-orbitar, and temporal arteries. The *Veins* for the most part correspond to and take the same course as the arteries. The Ophthalmic vein terminates in the cavernous sinus.

*Nerves.*—The largest and most important of these is the *Optic*. It enters the orbit by the optic foramen, where it receives a strong coating from the dura mater: it then decreases in size, and inclines forwards and inwards, so as to perforate the sclerotic a little inferior and internal to the axis of the globe: the expansion of the retina has been already described. The appendages of the eye are supplied by sensitive nervous filaments from the fifth, and by three motor nerves. The *Ophthalmic* nerve, after leaving the Casserian ganglion, crosses the cavernous sinus between the fourth and sixth nerves, and then divides into three branches just prior to entering the orbit by the lacerated foramen. The frontal branch is the highest and largest, and runs forwards and inwards to the pulley of the oblique muscle, through which one of its filaments passes to the forehead,—the other escapes by the supra-orbitar foramen: they supply the frontal region, even to the vertex. The lachrymal nerve terminates in the gland of that name and upper eye-lid; in its course thither it communicates with the infra-orbitar nerve by the spheno-maxillary fissure, and sends a filament through the malar bone to join the facial. The Nasal branch enters the orbit between the heads of the abductor oculi muscle, and crosses to the inner side of this cavity, where it divides into an infra-trochleator

* For further particulars, see 'Muscular System,' p. 411.

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branch which supplies the eye-lids and neighbouring skin; and a proper nasal, which enters the skull by the anterior internal orbitar foramen, and then descends with the olfactory nerve, as already described.* The third nerve is also named *Common Oculo-muscular*: it lies highest up in the cavernous sinus, and then bifurcates as it enters the orbit by the lacerated hole, where the nasal and lachrymal branches of the fifth are interposed between its divisions. The superior branch supplies the levator palpebræ and levator oculi; the inferior and larger is distributed to the depressor, adductor, and inferior oblique muscles. The fourth, or *Pathetic* nerve, mounts above the third as it enters the orbit, and terminates in the superior oblique muscle exclusively. In like manner the sixth, or *Abducent* nerve, which all along occupies the lowest position in its course, enters the ocular surface of the external rectus muscle, in which it is lost. The iris is supplied by nervous filaments from a small *ganglion*, named *Lenticular* or *Ophthalmic*. This little ganglion is placed on the outer side of the optic nerve, between it and the abducent muscle; it receives filaments of communication from the nasal nerve and inferior oblique branch of the third, and gives off, in common with the former, the ciliary nerves which accompany the arteries of the same name to the ciliary circle, and are distributed to the iris; this structure thus derives motor and sensitive, as well as sympathetic filaments, which latter join the nasal nerve prior to its communicating with the ganglion.

*Physiology.*—When rays of light, or undulations, are directed to the eye they impinge upon the retina, and are thence conducted by the optic nerve to the sensorium: the result is vision. The essential and fundamental part of this, as of the other senses, is, therefore, the nerve of specific sensation; the other constituents of the organ are for support and protection, and for qualifying the rays of light in their progress. It should be remarked that all our knowledge respecting the mode by which light impresses the retina is purely speculative.† The uses of each part of the organ of vision will be briefly considered. The eye-brow and lashes protect the eye by limiting, if needed, the quantity of light admitted, as well as by helping to exclude extraneous particles of matter. By the approximation of the eyelids the whole surface of the anterior part of the globe is covered or swept at pleasure; light may be thus excluded, and the exposed surface of the eye-ball moistened and cleansed. In this operation the upper lids descend three-fourths of the distance to meet the lower. The secretion by which the surface of the globe is moistened is derived from three sources; the lachrymal gland secretes the tears, the conjunctiva pours out its own peculiar secretion, and the Meibomian glands lubricate the margins of the tarsi. The superabundant fluid is usually conveyed to the nose through the puncta, lachrymal ducts and sac, and nasal duct; but under unusual circumstances, as in weeping, the copious and sudden secretion is poured out upon the cheek. The agency of mental influence on this little gland is remarkable and interesting, but equally unintelligible. The reflection of the conjunctiva from the lids to the eye-ball prevents extraneous particles from insinuating themselves behind the latter. The sclerotic membrane gives form and support to the eye. The prominence of the cornea is probably for the purpose of augmenting the sphere of vision; the rays of light undergo some refraction in their passage through this structure. The Aqueous humor is a second medium through which the rays proceed; but the principal use of this fluid is to preserve the equal convexity of the cornea (which collapses on its escape), and to allow of the free action of the floating iris. The Crystaline lens collects and rapidly concentrates the luminous rays, which have still to traverse a fourth medium, viz., the Vitreous humor; this last body also gives its spherical form to the globe, equally distending the tunics, and thus facilitating the different motions of the ball. The effect of the adaptation of these varied media to each other is to produce an achromatic instrument which corrects decomposition; whilst the diameter of the axis of the globe is so proportioned to the focal distance of the lens as to permit the image of an object to be justly formed on the retina. The choroid coat absorbs the transmitted rays of light; and the Iris, by its contraction or dilatation, augments or diminishes the pupillary aperture, and thus regulates the admission of light to the retina. The actions of the muscles moving the globe have been already described

* See 'Sense of Smell.'

† The reader is referred to the article 'Optics' for information on the nature and properties of light.

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# ANATOMY.

## SECTION IV.

### OF THE NERVOUS SYSTEM.

Anatomy. In the section which treats of the "Structure and Functions of the Nervous System," three distinct divisions have been noticed under the several titles of *Cerebral*, *True Spinal*, and *Sympathetic* or *Vegetative*. In the first and last of these, anatomists are enabled to identify structure with function; but the present state of knowledge does not supply the analogous connexion between the True Spinal or Excito-motory functions and their corresponding source or centre; in other words, there is as yet no satisfactory demonstration of the true seat of the functions last alluded to, although experiment leaves no doubt that a section of the spinal marrow constitutes the centre (or series of centres) of the Excito-motory system, and that filaments or offsets from this central source accompany most, if not all, of the spinal and some of the cerebral nerves in their course and distribution.* It has seemed desirable to introduce the present subject with the above prefatory remarks, in order to anticipate any misconstruction of the division which will be adopted in this the *Anatomical* description of the nervous system. Two sets of nerves, with their corresponding centres, will, therefore, present themselves for notice; viz., the Cerebro-spinal and Sympathetic; and the following order of description will be followed:—1. Cerebro-spinal System—*a.* Brain and its coverings; *b.* Spinal Cord and its coverings; c. Cerebral Nerves; *d.* Spino-sacral Nerves. 2. Sympathetic System—*a.* Ganglia; *b.* their branches.

The Brain is invested by three coverings, the Dura Mater, which is for support; the Arachnoid, which is a serous membrane; and the Pia Mater or vascular covering. The *Dura Mater* is a tough white fibrous membrane lining the Skull, of which it forms the internal periosteum, and to which it is more or less adherent at different parts, but especially so in the base and at the sutures. It lines the various apertures which transmit vessels and nerves in and out of the Skull; at these spots the dura mater becomes continuous with the external periosteum, which is likewise the case in the young subject at the sutures; it is also identified with the orbitar periosteum at the sphenoidal fissure; and a prolongation (to be presently described) accompanies the spinal marrow in its course through the vertebral canal. Certain folds or productions of the dura mater form septa between different parts of the brain, and at the same time serve the purpose of preserving from pressure the veins (sinuses) contained between their layers. The falx major or cerebri extends longitudinally between the hemispheres of the cerebrum, commencing narrow at the crest of the ethmoid bone, and extending to the internal occipital protuberance. The Falx cerebelli or minor is a continuation of the preceding forwards to the occipital foramen; it is interposed between the hemispheres of the Cerebellum. The Tentorium is a transverse partition separating the cerebrum from the cerebellum; it corresponds to the transverse grooves of the occipital bone and the superior angles of the petrous bones; a prolongation of the extremities of this fold along the small wings of the Sphenoid bone are called the Sphenoidal folds, and they correspond to the fissures of Sylvius. The principal arterial supply to this membrane is derived from the great meningeal branches of the Internal Maxillary Artery: they enter the Skull by the spinous foramina in the Sphenoid bone, and deeply groove the parietal bones in their course upwards and backwards to the vault of the Skull. Other and minor branches are derived from the internal carotid, ophthalmic, ascending pharyngeal, occipital, vertebral and posterior aural arteries, and enter the Skull by different foramina in its base. The *Sinuses* are venous canals contained between folds of the Dura Mater, and are constituted of this membrane externally, and the common lining membrane of the veins within; they are either single or in pairs. Of the single sinuses, the Torcular Herophili occupies a central position opposite the internal occipital protuberance. The superior Longitudinal sinus commences at the foramen cœcum of the ethmoid bone, and extends along the upper border of the falx to the Torcular, receiving in its course the veins from the surface of the cerebral hemispheres. The inferior longitudinal sinus is small, and occupies the concave border of the falx major; it collects blood from the corpus callosum, and terminates in the next. The Straight sinus corresponds to the base of the falx, and leads from the last to the Torcular; it receives the blood of the interior of the brain by the Venæ Galeni, and also branches from the cerebellum. The following sinuses are in pairs;—the Occipital run from the margins of the occipital foramen posteriorly to the Torcular. The lateral sinuses are capacious, and communicate between the Torcular and jugular veins; the bone is deeply grooved by them, and they correspond to the attached margin of the Tentorium as far forwards as the posterior lacerated foramen in the base of the Skull, where the jugular vein commences; they receive blood from both cerebrum and cerebellum. The Cavernous sinuses are placed on either side of the body of the Sphenoid bone, and the two communicate by two single sinuses, viz., the transverse sinus, which stretches across the basilar process of the occipital bone, and the circular, which surrounds the pituitary body. The superior Petrosal sinuses are a pair extending along the superior angles of the pe- Anatomy.

* The only probable hypothesis hitherto broached upon the subject is that of Mr. Grainger, who believes he has discovered, in the *cineritious* substance of the cord, the True spinal centre.



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trous bones between the cavernous and lateral sinuses: and the inferior Petrosal, which lie between the above-named bones and the occipital, have similar communications to the last. Some of the sinuses, especially the superior longitudinal, have fibrous bands stretched across their interior, apparently to limit their distention; and little granular bodies are developed about the orifices of the veins, probably to assist in directing the current of the blood.* The free communication of the sinuses and their incompressibility, as well as limited distensibility, are circumstances of vital importance to the integrity of the delicate organ with which they are connected.

The *Arachnoid* membrane invests the surface of the brain, sends a process into its interior, and lines the dura mater, to which it firmly adheres throughout its whole extent, except at the sella turcica. The visceral and parietal layers are continuous at the points of exit or entrance of the vessels and nerves. This membrane does not dip into the interstices of the convolutions, and is more loosely connected to the brain on its under than on its upper surface. The internal division of the Arachnoid communicates with the external at a small aperture (foramen of Bichat) placed between the posterior margin of the corpus callosum and the cerebellum, and thence spreads out beneath the veins of Galen and a fold of pia mater, denominated "velum interpositum," to be presently noticed: it also lines all the ventricles (except the fifth), traversing the apertures of communication between them. The perfect smoothness and lubrication of the opposed surfaces of this membrane are important properties in connexion with the organ it invests.

The *Pia Mater* or vascular membrane immediately invests the brain, not only covering its surface, but also lining the interstices between the convolutions: by this arrangement a very extended superficies of the cerebral structure is brought into direct contact with the net-work of vessels which constitute this delicate tissue. A reflection of the pia mater also spreads in the interior of the brain, through a broad fissure, which is bounded by the corpus callosum and pons Varolii in the centre, and extends between the thalamus and hippocampus major laterally: this is denominated "velum interpositum," and the margins are called "plexus choroides."

In the dissection of the encephalon its physical characters are found to differ at various parts, presenting in some places a reddish-brown, and at others a pearly-white appearance: these component structures are severally called cineritious and medullary. The former, or cineritious matter for the most part invests the latter, but the medullary exists in more abundance.

The bulk of the brain consists of a larger and smaller portion, named "Cerebrum" and "Cerebellum;" and each of these divisions is further divided into symmetrical halves by a longitudinal fissure, at the same time that they are united and connected by means of commissures which stretch from side to side: moreover the larger and smaller brain are joined to each other, and associated with the spinal cord by other commissures, which will be noticed in the course of the dissection. The longitudinal fissure which divides the *Cerebrum* into its two hemispheres is very deep, and lodges the greater falx. The superior surface of this division of the Brain corresponds to the vault of the cranium, and is consequently convex in each direction. The convolutions are irregular and variable in form, size, and direction, and are separated by deep fissures: these characters are less prominently developed on the under surface of the cerebrum. Each hemisphere is subdivided into lobes by a curved fissure (F. Sylvii); that portion resting beneath the tentorium has been called the posterior lobe, though undistinguished by any fissure similar to that which marks the separation between the anterior and middle lobes. The orbitar plates of the frontal bone support the anterior lobes, and the great wings of the sphenoid the middle. When the under surface of the cerebrum is viewed, it will be perceived that it is connected to a central protuberance (Pons Varolii) by two processes (crura), and these are crossed by bands of medullary matter (tractus optici), which unite anteriorly to form the optic commissure whence the nerves spring. In the diamond-shaped space thus bounded are seen two little pea-shaped bodies (corpora mammillaria), anterior to which the pituitary body is seen connected to the brain by a hollow peduncle named infundibulum, and behind them the medullary matter is pierced with vessels (locus perforatus). It has been remarked that the cerebral hemispheres are connected by commissures: there is, nevertheless, a considerable interspace, which has been described under the title of "Third Ventricle." The lower wall or floor of this inter-cerebral space is formed by the parts enumerated above as contained between the crura cerebri and optic tracts: its sides are formed by two bulbous swellings (optic thalami), which are connected by a short flat band of cineritious matter (soft commissure). By an aperture in its floor this fissure communicates with the infundibulum; and posteriorly, here is a passage leading beneath the optic tubercles to the grooved upper surface of the medulla oblongata (fourth ventricle). Covering in the inter-cerebral fissure is the membranous veil (velum interpositum) already described. Above this veil are found the three great cerebral commissures. When the cerebral hemispheres are separated, an extended mass of medullary matter is brought into view (corpus callosum): this consists of transverse fibres stretching into either hemisphere, and extending to their cineritious exterior: the extremities of this great transverse commissure are rounded or folded on themselves. Above this, and running along the margin of the longitudinal fissure on either side, are the fibres which connect the different lobes of each hemisphere together (superior longitudinal commissure). The Inferior longitudinal commissure (fornix) is interposed between the great transverse commissure and the veil of pia mater, and thus overhangs the central fissure called third ventricle: it consists of longitudinal medullary fibres, splitting before and behind, but united in the centre: the anterior pillars descend in front of the middle ventricle, and terminate in the corpora mamillaria and crura cerebri; whilst the posterior are found investing certain convolutions in the posterior lobes (hippocampi). A double vertical layer of medullary matter (septum lucidum) connects the transverse with the inferior longitudinal commissure: the intervening fissure is called "fifth ventricle." In front of the anterior pillars of the fornix, a rounded band of medullary matter extends between two pyriform bodies (corpora striata);

* The reader is referred back to this description, when studying the organisation of the brain.

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this is the anterior commissure. Behind the third ventricle are the optic lobes, four in number (nates and testes); upon the upper surface of which is resting a little grey body (Pineal gland), connected by peduncles to the optic thalami; and anterior to this is the posterior commissure, uniting the optic thalami at their junction to the optic lobes. Processes of medullary matter proceed from the last-named bodies into the interior of the cerebellum, constituting commissural bands between the great and small brain and spinal cord: the inner borders of these are connected by a thin plate called "Valve of Vieusseus." If the interior of the cerebral hemispheres be examined, their folded arrangement will be found to produce the appearance which has given rise to the description of lateral ventricles or cavities within the brain. Here, on either side of the median fissure, are seen the anterior and posterior cerebral ganglia (corpora striata and thalami nervorum opticorum), which are severally denominated the "ganglia of motion and sensation." They are partly overlapped by the borders of the velum interpositum (plexus choroides), and present in the interval between them a narrow band of medullary matter (tænia semicircularis). In the posterior extremity of the lateral ventricle, so-called, is a small convolution, denominated "hippocampus minor;" and a larger one (hippocampus major) lies in that part of the fissure which communicates with the base of the brain: the inner border of the latter is sharp and free (tænia hippocampi). The broad transverse or horizontal fissure, with the vertical or inter-cerebral fissure, establish a communication between the lateral and middle ventricles.

The structure of the *Cerebellum* presents an analogous arrangement to that already described in the Cerebrum, as regards the relative position of the medullary and cineritious matter; but in place of convolutions, the surface presents a series of lamellæ or plates separated by fissures, which admit the pia mater. A similar disposition also exists of division into symmetrical hemispheres, which are connected by commissures. Of these, one extends along the posterior aspect of the cerebellum, projecting into the great fissure above and below, and known by the name of "Vermiform processes;" the other is more distinctly commissural in its character, consisting of transverse fibres which constitute the superficial part of the mesocephalon (*Pons Varolii*) and the crura cerebelli. It may be here observed, that the interior of the Pons presents the longitudinal fibres of the motor and sensory tracts, passing from the cord to the cerebral hemispheres by the crura cerebri. In the last-named bodies these tracts are separated by grey matter of a very deep colour (*locus niger*). The interior of the cerebellum exhibits the relation of its component structures, of which the medullary is derived from three sources—viz., the inter-cerebral commissures, the great transverse cerebellar commissure, and the posterior columns of the cord. Recent dissection has also shown that the anterior columns likewise contribute some fibres.* A vertical or horizontal section of the cerebellum exhibits the appearance termed "arbor vitæ," the distribution of the medullary interior in its cineritious capsule presenting an arborescent arrangement, whence the name. An irregular oval line of the dark, within the white, matter has received the name of corpus dentatum.

* Solly, *On the Brain*, p. 157.

The *Spinal cord* is connected to the brain above under the title of "Medulla oblongata," and terminates in the upper lumbar region by forming the "cauda equina." Its coverings are continuous with those of the encephalon, the dura mater and arachnoid being both more loosely connected to the canal and cord than they are to the skull and brain. The fibrous membrane leaves the foramina with the Spinal nerves, and then becomes continuous with the adjoining cellular membrane. The arachnoid is reflected from the nerves at their exit, and forms a cul-de-sac or tubular prolongation in the sacral canal. The investing membrane of the cord, though continuous with the pia mater, is very different in texture and consistence, being tough, dense, and resisting; it is also more sparingly and less uniformly vascular than the cerebral pia mater. A line of angular fibrous processes descends, under the name of "Ligamentum dentatum," between the roots of the Spinal nerves. The superior is the most expanded part of the cord, which also presents other swellings opposite the origin of the brachial and lumbar nerves. In form the medulla spinalis is cylindrical, and, with the above exceptions, gradually diminishes in size as it descends; and first forming at its lower extremity an oval expansion, then terminates in a short conical process, which is surrounded by the cauda equina. There are six longitudinal grooves or fissures in the Spinal cord—two median and four lateral. The former are deep, the latter shallow. Of the median fissures the anterior is the deeper, and the two cut the cord so as to give it the appearance of two rounded columns placed side by side, and flattened where they are in contact. The bottom of the anterior sulcus presents transverse medullary fibres. The anterior and posterior lateral grooves are very shallow, and mark the lines of origin of the double roots of the spinal nerves. The relation of the white and grey matter in the cord is transposed, the former enveloping the latter. The medullary matter exceeds the cineritious in quantity, and the latter exists in greater abundance in the cervical and lumbar regions—a fact which seems to support the hypothesis of a connexion between this structure and the true spinal centre, as it is from these spots that the largest nerves spring. The form of the cineritious interior of the cord presents, on transverse section, the appearance of two crescents, with their convexities looking inwards and connected. Either half of the medulla spinalis is divided into anterior and posterior columns, or the columns of motion and sensation. As these ascend they are divided above in the medulla oblongata by an interposed eminence of grey covered by white matter, named "corpus olivare." In this, the upper extremity of the cord, the anterior pillars are called "pyramidal," and the posterior "restiform" bodies. The lumbar and sacral nerves take a long course from their origin before they emerge from the vertebro-sacral canal; the resulting appearance is the "cauda equina."

*Cerebro-spinal Nerves.*—All the nerves arising from the brain and spinal cord are in symmetrical pairs, and their usual form is cylindrical. With but few exceptions they take a direct course to their destination, very rarely deviating in their origin, or importantly so in their distribution. The "anastomoses" of nerves are frequent, whether with their fellows, with others possessing similar functions, or those of a different character. Where this interlacement is complex, it is designated

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Anatomy. by the title "Plexus." It should ever be borne in mind that the anastomoses of nerves consist in a simple interchange of fibrils; in no instance is the identity of a single ultimate filament lost throughout the whole of its course.

*Cerebral Nerves.*—Under the above head are included all the nerves originating from the brain and upper part of the spinal cord, with the exception of the sub-occipital; and these are generally classed into "pairs," according to their association at their exit from the skull. It need scarcely be remarked that this classification is most unscientific; but it imports little to the student who is first made acquainted with the above fact, and has, at the same time, placed before him a classification founded upon the stricter principle of their physiology. This will be first attempted in the following tabular view, which may be referred to in the succeeding description of the nerves under the numerical appellations by which they are generally known.

Classification of Cerebral Nerves according to their functions:—

| | | |
|---|---|---|
| Simple. . | Specific Sensation | 1st, or Olfactory.<br>2nd, or Optic.<br>Auditory division of 7th. |
| | Motion . . . | 3rd, 4th, 6th, 9th.<br>Facial of 7th. |
| Compound | Sensation and motion. . . | 8th. |
| | Sensation, motion, and specific sensation . . . | 5th. |

Probably all of the above belong, either as Excitors or Motors, to the True Spinal or Excito-motory System.

The first pair of Cerebral Nerves, or *Olfactory*, are connected to the posterior margin of the anterior lobes of the cerebrum. Each nerve has three attachments,—an internal to the fore and under part of the corpus callosum; an external, which extends along the fissure of Sylvius; and an intervening central peduncle. The resulting ganglion, rather than nerve, is prismatic in form, and lies in a groove on the under surface of the anterior cerebral lobe, and expands into an oval bulbous enlargement as it lies on the cribriform plate of the ethmoid bone, just prior to the descent of its filaments through the foramina in this bone.*

The *Optic* nerves, or second pair, take their cerebral origin from the tubercula quadrigemina by two distinct bands, which join corresponding elevations on the Optic thalami, known by the name of "corpora geniculata." A flat white band (*tractus opticus*) results from the union of these fibres, which takes its course downwards, forwards, and inwards, around the crus cerebri of the same side; and gradually assuming a cylindrical form, the aggregated fibres converge, and ultimately unite on the olivary process of the sphenoid bone to form the optic commissure, whence the nerves proceed to their destination. Prior to this union a few delicate fibres connect the optic tract to the tuber cinereum. The commissure is not uniform in its structure and the relation of its component fibres, but there is usually a distinct interchange of filaments between the nerves of either side at their point of contact.

* For the *distribution* of this and other nerves connected with the Senses, the reader is referred to that head.

The Third pair of nerves are called *common Oculo-muscular*. They are connected to the motor tract at the inner margin of each crus cerebri, near its junction to the mesocephalon. They take their course between the posterior cerebral and superior cerebellar arteries towards the cavernous sinus, resting on the attachment of the tentorium to the posterior clinoid process of the sphenoid bone. All the ocular muscles, except two, are supplied by these nerves. Anatomy.

The fourth pair, or *Pathetic*, spring from the inferior of the optic tubercles (testes) at their junction to the plate which connects the inter-cerebral processes (valve of Vieusseus). They wind round the crura cerebri, and emerging between the cerebrum and cerebellum each nerve follows the concave border of the tentorium and pierces the dura mater, to enter the cavernous sinus at a point a little external to the third nerve.

The fifth pair of nerves are also styled *Trigeminal*, from their threefold destination. They are types of the spinal nerves, consisting of two roots, a non-ganglionic or motor, and a ganglionic or sensitive origin. Of these roots, the former is anterior and smaller, and derives fibres from the motor tract in the crus cerebri, whilst the posterior and larger division may be traced back through the pons to the interval between the olivary and restiform bodies at the summit of the spinal cord. Each perfect nerve then passes to the petrous bone, on the point of the superior angle of which a depression exists, in which it is lodged. In its passage thither the small white bundle of fibres is covered by the broad, flat, fascicular division which constitutes the posterior root. This latter terminates on the point of bone above mentioned, in a large greyish-red semilunar ganglion, the concavity of which faces backwards and inwards. From the convexity of this, the Casserian Ganglion, three nerves proceed, severally denominated Ophthalmic, Superior, and Inferior Maxillary. The motor root retains its independence as it passes beneath the ganglion, and then joins the inferior maxillary nerve. The Ophthalmic nerve soon enters the cavernous sinus, and there receives filaments from the superior cervical ganglion of the sympathetic prior to its ultimate division. The superior Maxillary nerve is somewhat larger than the Ophthalmic division, and passes forwards and outwards to the round hole in the sphenoid bone, by which it escapes from the skull; it then crosses the spheno-maxillary fissure to the infra-orbitar canal, along which it takes its course, and emerging on the cheek divides into its ultimate filaments. The branches of this nerve are divided into three classes, according to their points of origin: 1. In the spheno-maxillary fossa the orbitar branch is separated, which enters the orbit by the spheno-maxillary fissure, and divides into a temporal and malar twig: the former pierces the upper part of the malar bone to arrive at the temporal fossa, where it communicates with filaments from the inferior maxillary nerve, and terminates in the skin of the temple; the latter escapes also through the malar bone to terminate on the cheek. Two short vertical filaments next descend from the superior maxillary nerve to join the spheno-palatine ganglion. Immediately afterwards the posterior superior dental are given off; they wind round the tuberosity of the upper jaw, which they perforate, to supply the molar teeth, a few filaments being given to the gums and periosteum. 2. Whilst in the infra-orbitar canal the anterior superior dental are separated; they

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descend along the anterior wall of the antrum (which they supply), and terminate in the incisor, canine, and bicuspid teeth of the upper jaw. 3. The terminating branches of the nerve emerge from the canal by the infra-orbitar foramen, and are distributed relatively to the regions denoted by their names—Malar, Nasal, Palpebral, and Labial. The Inferior Maxillary, or largest division of the trifacial nerve, passes out of the skull by the oval hole of the sphenoid bone; it is then found lying in contact with the external pterygoid and tensor palati muscles, and may be seen to consist of two distinct portions,—the anterior and external being the non-ganglionic white root already noticed, whilst the other and larger part partakes of the characters common to it and the other divisions of the nerve already described. The branches of the motor root are exclusively distributed to the muscles of mastication, and are the following: temporal filaments, which cross the external pterygoid muscle to gain the temporal fossa, where they terminate in the temporal muscle, and by communicating in the scalp with the facial nerve. The Masseteric also crosses the external pterygoid muscle, and then runs between it and the temporal to terminate in the masseter, after supplying the temporo-maxillary articulation. The Buccal takes its course between the internal pterygoid muscle and ramus of the jaw to the buccinator muscle, crossing first the coronoid process; it gives filaments to the pterygoid and temporal muscles, and then terminates in the buccinator: sometimes a separate branch or branches supply the pterygoid muscles. The sensitive or ganglionic division of the nerve divides into three branches. The Temporo-auricular passes backwards behind the neck of the lower jaw, and then upwards between its condyle and the external auditory opening; after which it issues from the parotid gland, and accompanies the temporal artery in its divisions: its filaments are distributed to the external ear, glenoid articulation, and skin of the temple, where it communicates with the facial. The Inferior Dental branch first runs between the pterygoid muscles, and then between the pterygoideus internus and ramus of the jaw to the inferior dental hole: prior to entering the canal a filament is separated, named mylo-hyoidean, which supplies that muscle, the digastric, and the sub-maxillary gland. In the dental canal filaments are distributed to the several teeth of the lower jaw, a large division of the nerve being separated at the mental foramen, where it emerges, and terminates in the muscles, skin, and mucous membrane of the lower lip and chin. The Lingual branch at first accompanies the last described, but separated from it by the internal lateral ligament of the lower jaw; it then descends obliquely behind the last molar tooth to the interval between the sub-maxillary gland and mucous membrane of the mouth, and joining the duct of the former crosses the insertion of the hyo-glossus muscle and above the sub-lingual gland, to terminate on the tongue. The filaments this distributes in its progress are, to the internal pterygoid muscles, to the mucous membrane of the mouth, the tonsils, gums, side of the tongue, and upper part of the pharynx; its termination has been already described. *Physiology*.—The Fifth is a compound nerve of motion and sensation, differing only from the spinal nerves in the non-amalgamation of their separate roots. The motor portion of the nerve superintends the acts of mastication, whilst the posterior root becomes the sensitive nerve of the forehead, face, tongue, palate, &c.; and its lingual branch appears also to be the nerve of taste. Each division appears further connected relatively with the excitor and motor functions of the true spinal system.



The sixth pair, or *Abducent* nerves, spring from the upper extremity of the pyramidal bodies of the medulla oblongata, at their junction to the mesocephalon. Each pierces the dura mater to enter the cavernous sinus just behind the posterior clinoid process of the Sphenoid bone; and, in its course through the sinus, is closely applied to the outer side of the carotid artery, where it receives filaments of communication from the carotid plexus of the sympathetic. It supplies the abductor muscle of the eye.

Under the head of seventh pair of cerebral nerves, two are classed together which have nothing in common save their aperture of exit from the skull—the Portio mollis, or *Auditory* nerve, and Portio dura, or *Facial*. The former is connected, at its cerebral extremity, to the upper part of the medulla oblongata by two sets of fibres enclosing the restiform body, the posterior of which may be seen in the form of transverse white lines crossing from the grooved fissure of the cord (the fourth ventricle). These converging filaments are collected at the angular junction of the mesocephalon with the crus cerebelli and corpus restiform, whence the nerve proceeds to the internal auditory foramen, which it enters accompanied by the portio dura. The Facial nerve arises from the upper part of the motor tract of the cord at its junction to the mesocephalon, emerging external and posterior to the fifth and sixth nerves; it is usually connected, soon after its origin, by a few filaments to the auditory, anterior to which it lies. In the internal auditory passage the facial is the internal of the two, and soon quits its consort to enter the aqueduct of Fallopius, which it traverses, and makes its exit by the stylo-mastoid foramen. Whilst in the aqueduct the muscular filaments to the tympanum are separated, and, immediately after leaving the skull, the three following branches are given off: Posterior auricular, which winds before the mastoid process to divide into twigs, which are distributed to the concha, auricular, occipito-frontalis, and sterno-mastoid muscles; the Sub-mastoid enters the posterior belly of the digastric muscle, which it supplies, also communicating with branches of the par vagum; the Stylo-hyoid branch supplies the Styloid muscle, and communicates with the superior cervical ganglion. The facial trunk now takes its course downwards and outwards through the parotid gland, and, whilst still imbedded in its structure, bifurcates immediately after crossing the external carotid artery, close to its ultimate division: the resulting branches are severally named temporo-facial and cervico-facial, and the interlacement from subsequent interchange of filaments is the parotidean plexus (Pes anserinus). The temporo-facial division is the larger; it passes upwards through the structure of the parotid gland, and, crossing the condyle of the lower jaw, subdivides into temporal, malar, and buccal branches: the first of these supplies the temporal, frontal, and auricular muscles, and communicates with the other nerves in these regions; the malar twigs cross the bone of that name, to supply the muscles of the cheek and upper lip; the buccal are transverse, crossing the masseter with the parotid duct, and supplying the muscles of the upper

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lip, alæ nasi, and commissure of the lips; many filaments also communicate with the motor and sensitive portions of the fifth on the cheek. The Cervico-facial division of the facial trunk passes downwards through the parotid to the angle of the lower jaw, where it subdivides into supra-mental filaments, which supply the muscles of the lower lip, and the infra-mental, which run beneath the platysma, giving it filaments, and communicating freely with the cervical plexus. *Physiology.*—The Facial nerve is the motor nerve of the face, supplying those regions which derive their sensitive filaments from the fifth. It belongs to the motor section of the true spinal system.

The eighth pair of nerves consists of three divisions, which are classed together as they pass out of the skull in company. The *Glosso-pharyngeal* and *Pneumogastric* divisions arise by several filaments from the side of the medulla oblongata between the olivary and restiform bodies: they are joined by the third division, which is really a spinal nerve, arising from the spinal marrow by several filaments between the pneumogastric and fourth spinal nerve; it is the *Spinal accessory*. These three pass together to the posterior lacerated hole of the skull, by which they quit this cavity anterior to the jugular vein, the pneumogastric being placed between the other two nerves. The Glosso-pharyngeal first sends off a tympanitic branch which traverses the petrous bone to join the Vidian; and communicating also by other filaments with the facial and sympathetic, it takes its course around the stylo-pharyngeus muscle to its destination, which has been already described. The Pneumogastric nerves, or Paria Vaga, consist, at their origin, of eight or ten distinct fascicles belonging to either nerve, which, at their exit from the skull, are closely bound together and intimately connected to the lingual motor nerves. Each par vagum then presents a greyish gangliform enlargement, and subsequently pursues its course through the neck and chest to the abdomen. In the cervical region it lies upon the rectus capitis anticus and longus colli muscles, and in the carotid sheath between the artery and jugular vein. The right nerve then crosses the subclavian artery at right angles (being interposed between it and the vein), to pass into the thorax: the left nerve is on a plane posterior to its fellow, and descends between the subclavian and carotid arteries of that side, parallel to which it runs to gain the outer surface of the descending portion of the arch of the aorta. The two nerves then approach the median line, and pass behind the roots of the lungs into the posterior mediastinum, where they attach themselves to the œsophagus, and are conducted by it (the left being on its anterior, and the right on its posterior aspect) through the diaphragm to the stomach. *Branches.*—After communicating with the other neighbouring cerebral nerves and superior cervical ganglion of the sympathetic, the pharyngeal branch is separated, which descends obliquely inwards behind the carotid sheath, and close to the spine towards the pharynx: a plexus is here formed by this branch and other filaments from the glosso-pharyngeal and sympathetic, which supplies the pharynx. The superior laryngeal branch is given off almost immediately afterwards, and takes a similar course behind the carotid sheath to the side of the larynx, where it divides into external and internal filaments: the former are distributed to the thyro-hyoid, sterno-thyroid, and crico-thyroid muscles; the latter penetrates the thyro-hyoid membrane, and is distributed to the mucous lining of the larynx, and crico-thyroid and arytænoid muscles. The Vagus then communicates with the cervical plexus, and gives off its cardiac filaments (one on the left and three or four on the right side) to join the cardiac plexus, whither they are conducted by the carotid arteries. The recurrent laryngeal branch is given off whilst the nerves are relatively connected to the under part of the subclavian artery and upper part of the aortic arch, the former being encircled by the right and the latter by the left nerve; each recurrent branch then passes upwards and inwards under the carotid and inferior thyroid arteries and thyroid gland to the pharynx, beneath the inferior constrictor of which it takes its course to gain the posterior aspect of the thyroid cartilage: it communicates with the cardiac plexus and inferior cervical ganglion, supplying also the thyroid body and tracheal mucous membrane: its terminating filaments pierce the crico-thyroid membrane, and are distributed to the crico-arytænoideus lateralis and posticus, and thyro-arytænoideus, as well as the mucous membrane of the larynx, where it communicates with the superior laryngeal nerve and its fellow. Behind the root of each lung the great pulmonic plexus is formed by a net-work of filaments derived from the pneumogastric nerves (which here for a time almost lose their cord-like character), and from the lower cervical and first thoracic ganglia: similar but fewer filaments are detached to form an anterior pulmonic plexus in front of the pulmonary vessels: the branches from these plexus accompany the ramifications of the bronchi and terminate in their lining membrane. A similar plexiform arrangement may also be observed on the œsophagus, the filaments from which supply this tube. Lastly, in the abdomen these nerves form a network around the cardiac extremity of the stomach, from which filaments proceed, under cover of the peritoneum, to supply all parts of this organ, and to communicate with the neighbouring sympathetic plexus supplying the abdominal viscera. *Physiology.*—These nerves regulate, through their laryngeal branches, the muscular movements of the larynx, and are therefore essential to the production of voice; they further endow the mucous membrane of the laryngeal orifice with its very exalted sensibility. By their pulmonic branches, the pneumogastrics convey impressions from the lungs to the brain, whence the necessary motor influence is propagated along the phrenic nerves to regulate the movements of the Diaphragm. The cardiac branches preserve the sympathy between the heart, lungs, brain, and stomach: such is likewise the property of the gastric branches in part, though doubtless they are also necessary to the perfect performance of the functions of this organ, which are principally under the control of the sympathetic system. Probably the sensations of hunger and thirst are also referable to these nerves.

The Spinal accessory nerves ascend from their origin between the roots of the spinal nerves, and lie, in the lacerated foramina, behind the other divisions of the eighth, and to the outer side of the ninth: on emerging from the cover of the jugular vein, each nerve almost immediately perforates the sterno-mastoid muscle obliquely, and again appears on its posterior aspect, where its ultimate filaments are distributed to the trapezius muscle. It communicates in its course with the pneumo-gastric, lingual motor and cervical nerves, and

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supplies the sterno-mastoid muscle. *Physiology.*—These nerves control the actions of the muscles they supply, being also motor branches of the true spinal system.

The ninth, or *Lingual Motor* nerves, spring by ten or twelve distinct filaments from the motor column in the medulla oblongata, emerging from the fissure between the corpus olivare and pyramidale of either side. Each nerve descends outwards to the anterior condyloid foramen in the occipital bone, after which it becomes closely connected to the par vagum, being posterior to it and to its inner side. It subsequently hooks round the occipital artery, and crossing external to the carotid arteries and vagus nerve, it passes beneath the digastric and stylo-hyoid muscles in its progress to the tongue. It communicates with the pneumogastric, sub-occipital, and cervical nerves, and superior cervical ganglion, and gives off a long branch, called Descendens Lingualis. This nerve runs down the neck parallel to the carotid artery, and generally superficial to its sheath: it is usually reinforced by a branch from the vagus, and opposite the point of intersection of the sterno-mastoid and omo-hyoid muscles, it is met by communicating twigs from the cervical nerves, and a little triangular plexus is the result, from which filaments proceed to be distributed to the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles. This descending branch of the lingual nerve probably associates the actions of the muscles it supplies with those between the lower jaw, larynx, and tongue.

*Spino-Sacral Nerves.*—Under this head thirty pairs of nerves are classed, which escape from the vertebral canal by the spinal and sacral foramina. Their most prominent characteristics are that they are symmetrical; that they commence by double roots, of which the posterior is considerably the larger, and swells into a ganglion prior to joining the anterior; of these roots (which spring by several filaments from the lateral furrows of the cord), the former is exclusively sensitive and excitor, and the latter is endowed with motor properties. As these roots are passing the intervertebral foramen, and immediately subsequent to the formation of the ganglion on the posterior, they unite into a single cord or trunk, which again divides into anterior and posterior branches, of which the former is almost invariably the larger; the nerves, after this division, are composed of the mixed roots, and are, therefore, compound nerves of motion and sensation. In the upper region of the spine the nerves are nearly transverse in their direction as they leave the column; but they gradually become more oblique, and have a longer course within the spinal canal as the sacral region is approached.

The *Cervical* nerves are eight in number, of which the first emerges beneath the occipital bone (sub-occipital), and the last below the seventh vertebra of the neck.

The *posterior* branches of these nerves pass backwards between the transverse processes of the vertebræ to supply the posterior cervical muscles. The first two are, however, larger than the anterior branches, and require separate notice. The superior passes into the triangular space bounded by the posterior recti and obliqui muscles, to which and others in the neighbourhood it is distributed. The second nerve passes back between the superior oblique and complexus muscles, and after giving off a lash of muscular filaments, it is continued upwards in the scalp even to the vertex.

The *anterior* branches of the first four cervical nerves, after communicating with each other, coalesce to form the *Cervical plexus.* The situation of this plexus is in the posterior superior triangle of the neck, between the second and fifth cervical vertebræ, covered by the platysma and posterior border of the sterno-mastoid muscle, and lying internally on the anterior scalenus, and externally on the levator anguli scapulæ muscles; its branches are superficial and deep. The ascending *superficial* branches are three;—the auricularis, which ascends to the interval between the angle of the lower jaw and ear in company with the external jugular vein, and is lost in the parotid gland and external ear, where it communicates with the facial vein. The superficialis colli ascends towards the sub-maxillary gland, which it supplies, and likewise gives filaments to the platysma and digastric muscle, and to communicate with the facial and mylo-hyoidean nerves. The mastoid branch keeps the posterior border of the Sterno-mastoid muscle, and is lost in the occipital scalp and ear. The descending superficial branches are supra-clavicular and acromial; these take the directions their names denote, and are lost in the skin of the chest and shoulder. The *deep* branches communicate with the descending lingual nerve, and give off the muscular filaments already described (see ninth cerebral nerve); others descend beneath the clavicle to terminate in the axilla; of these, one long branch (external Respiratory of Bell) is connected with the phrenic and distributed to the Serratus magnus muscle. Lastly, the *Phrenic* nerve descends from the cervical plexus; it is derived from the third and fourth nerves, and gets an additional filament from the upper cord of the brachial plexus. This descends obliquely over the anterior scalenus muscle to its inner magin, being interposed in this course between the sub-clavian artery and vein. As it enters the chest it hooks round the internal mammary artery, and then crossing anterior to the root of the lung, it descends between the pericardium and pleura to the diaphragm. The left nerve is somewhat longer, and on a plane posterior to the right, having to wind round the apex of the heart. The scalenus muscle usually receives a filament from this nerve; but its destination is the diaphragm, of which it is the motor nerve, thus completing the excito-motor circle with the pneumogastric or centripetal nerve. Filaments from the Phrenic nerve pierce the diaphragm to join the abdominal plexus of the Sympathetic. In addition to the communications above noticed, the anterior branches of the upper cervical nerves communicate with the Sympathetic ganglia in the neck, and with the eighth and ninth cerebral nerves.

*Brachial Plexus.*—The anterior branches of the four inferior cervical nerves much exceed in size those of the superior, and passing outwards between the scaleni muscles, unite with the anterior branch of the first dorsal to form the plexus which supplies the upper extremity; prior to this union, muscular filaments, especially from the fifth and sixth nerves, are distributed to the anterior cervical muscles, levator scapulæ, serratus magnus, latissimus dorsi, and pectoral muscles; and communicating filaments are received by each from the cervical ganglia of the Sympathetic. Of the branches which constitute the brachial plexus, the upper descend to join the lower, which are nearly horizontal, and three nervous cords result from this union; the superior, consisting of the fifth and sixth

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cervical, the middle of the seventh alnne, and the eighth cervical and first dorsal nerve forming the inferior cord. The position of this plexus is in the posterior inferior triangle of the neck, above and a little behind the subclavian artery, being sometimes separated by a portion of the posterior scalenos muscle; it then descends outwards between the subclavius muscle and first rib, to enter the axilla, where it next lies on the upper digitation af the serratus magnus. The nerves then surround the artery and pass to their several destinations.

The Branebes af this plexus ara Thoracic, Scapular, and Brachial. The *Thoracic* nerves are two or three in number, and descend before the vessels to be distributed to the pectoral muscles; they come from the inferior part of the plexus, and communicate with the second intercostal nerve. The *Scapular* nerves vary in number: the supra-scapular is a large regular branch which passes from the upper part of the plexus to the superior eosta of the scapula, where it traverses the foramen completed by ligament, and subsequently descends beneath the acromion to terminate in the infra-spinatus and teres minor muscles: a subscapular branch is separated befare the nerve arrives at the supra-spinous fossa, and filaments are given to the muscle of that name in the last-mentioned space. The subscapular nerves are irregular; they accompany the corresponding artery in its distribution to the subscapular and teretes muscles. The *Brachial* branehes are large and numerous; they are related in the following way to the artery: the two heads of the median nerve join anterior to it; the inner cutaneous and ulnar are connected to the internal head of the last, and therefore lie to the inner side af the artery; the outer cutaneous is in like manner connected to the external head of the median, and the radial and circumflex nerves are behind the artery. The Circumflex nerve leaves the upper part of the plexus to join the posterior eircumflex artery in its exit from the axilla between the humerus, long head of the triceps, and latissimus dorsi muscles; it runs round the neck of the bone onder cover of the deltoid muscle, to which it is prineipally distributed; some filaments supply the joint, teres minor and infra-spinatus muscles, and others become cutaneous. The internal Cotaneous nerve proceeds from the lower part of the plexus, and accompanies the basilic vein beneath the fascia of the arm to the inner condyle, where its branches become cutaneous. After supplying the skin about the elbow, the internal or larger division of the nerve continues its course in company with the basilic vein, distributing its filaments to the anterior, inner, and back part of the fore-arm as low as the hand; the outer division is similarly disposed of on the anterior and external part of the fore-arm. Usually another small cutaneous nerve exists, which is joined by communicating filaments from the second and third dorsal nerves (Wrisberg's), and is distributed to the skin of the axilla and inner brachial region. The External or Musculo-eutaneous nerve leaves the middle of the plexus, and shortly perforating the coraco-brachialis muscle, descends between the flexors of the fore-arm ta the elbow, where it becomes sub-cutaneous; then, after erossing under the median cephalic vein, it traverses the fore-arm, and divides into anterior and posterior branches. In the above course it supplies the muscles with which it is in contact and the skin of the fore-arm, and its terminating filaments are lost in the skin of the thumb and that covering the second metacarpal bone. The Ulnar nerve is derived from the inferior cord of the plexus; it descends between the triceps and biceps muscles, in company with the inferior profunda artery to the inner condyle of the humerus, behind which it passes, and between the two heads of the flexor carpi ulnaris muscle; it then passes through the fore arm under eover of this muscle, and lying upon the deep flexor of the fingers to the inner side of the ulnar artery: it subsequently crosses superficial to the annular ligament to terminate in the palm. In the upper arm this nerve gives a few filaments to the triceps and neighbouring integument; in the fore arm it supplies many of the flexor muscles of the fingers: a large dorsal branch is separated about the middle of the fore arm, which winds round the ulna, and descends upon the extensor carpi ulnaris to the back of the hand, where it is distributed to the skin of the little and ring fingers. Of the terminating branches the superficial is the larger, supplying the palmar surface of the little finger and ulnar side of the ring finger; and communicating with the median, the deep branch passes between the abductor minimi digiti and long flexor tendons, supplying the muscles of the thumb and little finger, and anterior interossei. The Median nerve collects branches from all parts of the plexus, and after the union of its two heads it descends in front of the brachial artery, gradually inclosing to its inner side as they together approach the elbow; it then passes deeply into the fore arm between the supinator langus and pronator teres, separating the two heads of the latter muscle, and taking its subsequent course between the superficial and deep flexors of the hand; at the carpus it is seen between the flexor sublimis and flexar carpi radialis, and passing beneath the annular ligament it divides into its terminal branches. This nerve distributes large filaments to the flexors and pronators in the fore arm: an interosseous branch accompanies the corresponding artery for the supply of the deep flexors; it pierces the interosseous ligament below, and terminates on the back of the hand. The median then gives off a cutaneous palmar filament above the wrist, and divides into its digital branches, which are five in number: these cross the palm, and run in company with the digital arteries on either side of the thumb, fore finger, and middle finger, as well as the radial side of the ring finger, where a communication is established with the ulnar: the muscles of the thumb and lumbricales are also supplied by these branches. The Radial nerve is generally the largest of the plexus, from which it arises by several filaments from each af the cords; it takes a spiral course round the humerus, piercing the fibres of the triceps, between the inner and middle heads of which it first runs, and then between the outer head and bone; it is accompanied by the superior profunda artery, and near the elbow is found between the long supinator and anterior brachial muscles, where it divides into an anterior and posterior branch. In its course this nerve supplies the extensors of the fore arm, and extensors and supinators of the hand; and above its division a cutaneous branch (radial cutaneous) is separated, which descends on the outer and back part of the fore arm to the wrist. Of the terminating branches the anterior is the smaller; it accompanies the radial artery through the middle third af its course, and then winds close to the radius to the back of the fore arm: it is lost on the skin of the thumb, fore and

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 middle fingers. The posterior branch of the Radial nerve takes a deep course, piercing the supinator brevis close to the neck of the radius: it first supplies the extensor and supinator muscles, and subsequently descends on the posterior aspect of the interosseous ligament to the posterior annular ligament, beneath which it passes to be distributed to the dorsal interossei muscles and skin of the hand.

The *Dorsal Nerves* are twelve pairs, the last of which leaves the spinal canal between the last dorsal and first lumbar Vertebræ. The posterior branches in this region pass backwards between the transverse processes of the vertebræ and superior costo-transverse ligaments, and are distributed to the muscles and skin of the back and loins, the last communicating with the first lumbar. The anterior branches are the intercostal nerves, each of which receives, soon after its origin, one or two communicating filaments from the corresponding sympathetic ganglion of the chest. As the intercostal nerves pass outwards, they first lie beneath the pleura, and subsequently insinuate themselves between the intercostal muscles, and accompany the intercostal vessels in the groove on the under border of each rib: they terminate by dividing into internal and external branches. The former of these, after supplying the intercostal muscles, are distributed to the skin and muscles of the chest and mamma above, and to the abdominal muscles and integument below; the latter pierce the external intercostal muscles near the middle of the ribs, and terminate in the serratus magnus and abdominal muscles. The first intercostal nerve is the largest, assisting in the formation of the brachial plexus. The second and third give off the cutaneous brachial branches already noticed. The twelfth communicates with the first lumbar. Their length corresponds to the length of the ribs, and their position in the costal groove is superior to the artery.

The *Lumbar Nerves* are five pairs, of which the lowest leaves the spinal canal immediately above the sacrum. The posterior branches are distributed, as those in the dorsal region, to the lumbar muscles. The anterior branches communicate with the lumbar sympathetic ganglia, with each other, and with the last dorsal and first sacral nerves. The Lumbar plexus results from the union of these branches; it is imbedded in the psoas muscle, and rests on the transverse processes of the lumbar vertebræ. The following are the branches of this plexus: the Ilio-scrotal crosses the quadratus lumborum muscle to the crest of the ilium, and then piercing the transversalis muscle divides into two branches; one of these is distributed to the oblique muscles and skin of the buttock; the scrotal branch gains the internal ring, and is distributed to the groin and scrotum. The external Cutaneous nerve of the thigh pierces the abdominal parietes obliquely, and, emerging near the spine of the ilium, is distributed to the skin of the back and outer part of the thigh as low as the knee. The Genito-crural nerve passes beneath Poupart's ligament, and divides into an external spermatic branch, which is lost in the cord and scrotum, and a crural branch which supplies the groin and skin of the thigh. The Anterior Crural nerve is a large branch of the plexus, from different parts of which it is formed; after emerging from the psoas muscle, it descends between it and the iliacus, and beneath the fascia to the crural arch, through which it runs external to the femoral artery. The above muscles first receive filaments from this nerve, which then divides into superficial and deep branches: the former, three or four in number, pierce the fascia a little below Poupart's ligament, and are distributed over the skin of the thigh even to the knee. The deep branches are external, internal, and descending: the first of these are most numerous, and supply the extensors of the leg, the tensor vaginæ femoris and iliacus; the internal are lost in the vastus internus, pectinæus, and sartorius; and the descending are two,—the small saphenus, which supplies the lower part of the vastus internus and sartorius, between which it runs; and the great saphenus, which accompanies the femoral artery, lying on its outer side, to the opening in the adductor magnus: here this long nerve quits the femoral vessels, and accompanies the anastomatic artery round the inner condyle between the tendons of the sartorius and gracilis; and in the rest of its course it is found close to the internal saphena vein, with which it passes anterior to the inner malleolus to terminate on the dorsum of the great toe: it gives off two or three muscular filaments in the thigh, besides supplying the knee-joint and neighbouring skin. The Obturator nerve is derived principally from the third lumbar; it crosses the pelvis, between the fascia and peritoneum, to the opening in the thyroid membrane, where it escapes with the corresponding artery to terminate in the obturator and adductor muscles; one or two filaments become cutaneous. The Lumbo-sacral nerve is the last and largest branch of the plexus; it soon divides into two branches: the superior gluteal, which leaves the pelvis above the pyriform muscle, and is distributed to the two smaller glutei muscles; and the communicating branch, which crosses the gluteal artery to join the ischiatic plexus.

The *Sacral Nerves* are usually five pairs, the inferior leaving the canal between the sacrum and coccyx; the posterior branches are distributed to the skin of the nates and anus, and the anterior unite to form the Sciatic plexus. This large flattened band of nerves rests behind the pelvic viscera on the side of the sacrum and pyriform muscle, and becomes united into a single large cord at its exit from the pelvis; it presents no interlacement, but a simple junction of component trunks: the branches are visceral and femoro-crural. The former receive the names of Hæmorrhoidal and Vesical, and, in the female, Uterine and Vaginal are superadded; they are distributed with the branches of the Hypogastric plexus of the Sympathetic, accompanying the ramifications of the internal iliac artery. The Pudic nerve accompanies the artery of the same name in its course round the spine of the ischium; on re-entering the pelvis by the lesser ischiatic hole it divides into a superior and inferior branch: the former is guided by the rami of the ischium and pubes to the arch of the latter, beneath which it runs to gain the dorsum penis; its gives filaments to the urethra, muscles, and integuments, and terminates in the glans penis: the inferior, or perinæal branch, becomes superficial by passing between the erector penis and accelerator urinæ, and is lost in the perinæal and urethral muscles and integument: in the female, the former of these branches terminates in the clitoris; the latter in the labia, nymphæ, and pubic skin. The Femoro-crural branches of the sacral plexus are the small and great Sciatic nerves. The former of these springs from the middle and lower parts of the plexus, and leaves



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the great ischiatic hole above the pyriform muscle, when it divides into three branches: one, the inferior gluteal, is distributed to the great glutæus muscle; the second, or musculo-cutaneous, passes beneath the ischial tuberosity, and divides into filaments which supply the great glutæus muscle and the skin of the perinæum and inner region of the thigh; the posterior cutaneous is the largest and most external branch, which, after quitting the cover of the great glutæus, descends beneath the fascia to the ham, and here terminates in a lash of cutaneous filaments, having previously supplied other parts of the skin in its course. The great Sciatic nerve consists of the chief bulk of the plexus; it leaves the pelvis with the last described, although in some instances of high bifurcation the pyriform muscle is pierced by one division of it. The nerve then crosses in turn the gemelli, obturator, and quadratus muscles, and in its subsequent course through the thigh it lies on the adductor magnus near its insertion, and is overlapped by the hamstring muscles: the above muscles receive a few filaments from the nerve in its passage, and in or above the ham it divides into the two popliteal branches. The External of these is the smaller, and is directed by the biceps over the back of the outer condyle of the femur and head of the gastrocnemius muscle; it then winds beneath the long peroneus muscle round the neck of the fibula, in which short course it gives off muscular, cutaneous, and articular filaments, and one long branch (*communicans peronei*) which descends beneath the fascia to join a similar branch from the internal popliteal nerve; the terminating branches of the external popliteal nerve are the musculo-cutaneous and anterior tibial. The former, which is the larger, descends beneath the long peroneus, and between it and the long extensor of the toes; after leaving the former it continues to be covered by the crural fascia, which it pierces below the middle of the leg, and the rest of its course is cutaneous; it supplies the muscles with which it lies in contact, as well as the skin of the ankle and instep, and muscles and skin of the great toe, and then terminates by supplying the opposed margins of all the toes. The anterior Tibial nerve quits the last described beneath the peroneus longus, and gains the interosseal space by perforating the common extensor of the toes; it then descends in company with, and to the outer side of, the anterior tibial artery, being between the anterior tibial and common extensor muscles above, and between the former and extensor of the great toe below; and lastly, after passing beneath the annular ligament and tendon of the extensor pollicis, it is found between the latter and long extensor tendon. It gives filaments to the above-named muscles and knee-joint, and its terminating filaments supply the short extensor and dorsal interossei muscles, and the opposed borders of the first and second toes. The Internal Popliteal nerve takes a vertical course through the ham, posterior to the vessels and popliteus muscle, and covered by the fascia; it then passes deeply beneath the soleus muscle and deep fascia of the leg, and thence descends, under the name of posterior Tibial nerve, to the inner malleolus, where it bifurcates. In this course it lies to the outer side of the corresponding artery, and in succession upon the posterior tibial and long flexor muscles; in the lower fourth of the leg it is only covered by fascia. The first branch of this nerve is the communicans tibialis, which accompanies the smaller saphena vein down the leg, and, being joined by the communicans peronei, the resulting nerve is called posterior saphenus; it runs behind the outer ankle, to the skin of which it gives filaments, and ultimately terminates in the muscles and skin on the outer side of the little toe, and on the opposed margins of it and the fourth toe. In the ham, large muscular branches are separated from the internal popliteal nerve for the supply of the posterior muscles of the leg and of the knee-joint; lower down, the deep muscles of the leg receive their supply, and a communicating filament usually traverses the interosseal space to join the anterior tibial nerve; a few cutaneous twigs are likewise separated, and one regular branch is given to the skin of the heel and sole of the foot; lastly, the division into the plantar nerves takes place close to or beneath the origin of the adductor pollicis muscle, and behind the vessels. The inner plantar, which is the larger, runs above the adductor pollicis to the space between it and the flexor brevis; after supplying the plantar muscles it divides into four branches, which are distributed to the tibial side of the great toe and the opposed margins of the four inner toes. The external plantar nerve crosses the foot obliquely between the flexor brevis and accessorius muscles to the base of the fifth metatarsal bone; after giving off muscular filaments it here divides into a superficial branch which supplies both margins of the little toe and the outer border of the fourth, which latter communicates with the inner plantar; and a deep branch which crosses above the abductor pollicis, and terminates in the lumbricales, plantar interossei, and other deep plantar muscles.

*Sympathetic or Vegetative System of Nerves.*—This system consists of many sources of nervous influence, which are scattered over different parts of the head and trunk, and branches of communication and distribution which are offsetts from these ganglia. Those of the head will be first described.

*Ophthalmic Ganglion.*—(See ' Organ of Vision. )

*Spheno-palatine Ganglion* (of Meckel).—This ganglion is found in the pterygo-maxillary fossa, between the tuberosity of the upper-jaw and pterygoid process of the sphenoid bone on either side. From it two small filaments ascend to join the superior maxillary nerve. The inferior or palatine nerve descends through the posterior palatine hole to terminate in the arch of the palate and gums; a nasal filament passes from it through the palate-bone; and others supply the velum, uvula, and tonsils. The spheno-palatine branches pass inwards through the foramen of that name to the nasal fossa, in the mucous membrane of which most of them terminate; and one long filament is conducted by the nasal septum to the anterior palatine foramen, where a small ganglion is found (*naso palatine*), and whence filaments are distributed to the palate. The Vidian or recurrent branch passes backwards through the pterygoid foramen, and, after communicating with the carotid plexus, enters the skull by the anterior lacerated hole, and penetrates the petrous bone by a small foramen, which communicates with the Fallopian aqueduct; here it joins the facial nerve, on the under part of which it runs for a short distance, and then quits it to cross the tympanum (under the name of *corda tympani*), between the incus and malleus: it subsequently leaves this cavity by the glenoid fissure, and, joining the lingual branch of the fifth

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nerve, quits it at the posterior margin of the submaxillary gland, and terminates in the *submaxillary ganglion* by which the gland is supplied.

The *Otic Ganglion* is situated on the inner side of the submaxillary nerve just after the latter has quitted the skull: it distributes filaments to the tensor palati, internal pterygoid, and tensor tympani muscles; communicating with the sympathetic filaments on the external carotid artery, and with the third division of the fifth; and also giving off a filament which penetrates the petrous bone.

The *Superior Cervical Ganglion* is elongated in form, thick in the centre, and tapering at the extremities. It extends longitudinally over the second and third cervical vertebræ, resting on the anterior rectus muscle, and covered immediately by the internal carotid artery. Its ascending branches accompany the internal carotid artery, forming a plexus around it, and communicating with the Vidian nerve, the nasal branch of the fifth and the sixth nerves: one or two small ganglia may be remarked in tracing these filaments to their ultimate destination. A descending branch communicates with the middle ganglion of the neck, and aids in forming the cardiac plexus, likewise communicating with the cervical nerves. The anterior branches communicate with the seventh, eighth, and ninth nerves, and accompany the carotid and its branches. The external branches are large, and establish a free communication with the cervical plexus. Lastly, the internal branches supply the anterior cervical muscles, and join the pharyngeal and laryngeal plexus.

The *Middle Cervical Ganglion* is frequently absent, but when present is usually opposite the fifth cervical vertebra, of a rounded form, and lying between the carotid sheath and longus colli muscle. It communicates with the superior and inferior cervical ganglia, and the upper branchial nerves near their origin; it gives off a cardiac branch, and filaments to the thyroid body, trachea, and œsophagus.

The *Inferior Cervical Ganglion* is irregular in size, being larger in the absence of the last, and frequently coalescing with the first thoracic ganglion. Its position is between the transverse process of the last cervical vertebra and the head of the first rib, close to the vertebral artery. Besides its communicating branches with the ganglia above and below, and with the lower brachial nerves close to their origin, it sends filaments to join the pulmonary and cardiac plexus, and to accompany the mammary and scapular branches of the subclavian artery.

The *Cardiac Plexus* is a title given to an interlacement of nervous filaments between the bifurcation of the trachea and arch of the aorta. This plexus contains many small ganglia in its meshes, and receives the cardiac branches of the pneumogastric nerves, already described, as well as the three pairs of cardiac filaments from the cervical ganglia: these latter branches are irregular, and not symmetrical. On the right side, the superior cardiac nerve descends behind the carotid trunk to enter the chest between the subclavian vein and artery close to its origin: the middle nerve on the same side is large, and when the middle ganglion is absent, it springs from the connecting branch of the upper and lower ganglia, and crosses the subclavian artery external to the last: the inferior nerve of the right side passes behind the subclavian artery into the chest. On the left side, the superior cardiac nerve takes a deep course between and parallel to the subclavian and carotid arteries, by which it is conducted to the aorta; the middle filament is often absent on this side, its place being supplied by a larger inferior branch, which runs by the side of the subclavian artery to the aortic arch. The superior cardiac nerves communicate with the branches of the par vagum and lingual motor nerves. The principal destination of the branches of the cardiac plexus is to the structure of the heart, which they penetrate in company with the coronary arteries, posteriorly and anteriorly; some of the former filaments also accompany the pulmonary vessels to join the pulmonic plexus, and thus aid in supplying the lungs.

The *Thoracic Ganglia* are generally twelve pairs, the first pair being frequently identified with the lowest cervical. Their form is irregular, but usually triangular or ovoid, and as large as a grain of barley: their position is on, or a little below, the head of each rib, and they are covered by the pleura reflected from the sides of the posterior mediastinum. The branches of these ganglia are few, consisting of a communicating filament between those which are neighbours, and one, or sometimes two, which direct themselves upwards and outwards to join each intercostal nerve; irregular and small filaments join the pulmonic plexus, but the most important branches are those which constitute the splanchnic nerves. It should be further noticed that the first and last thoracic ganglia communicate relatively with the last cervical and first lumbar ganglia; and that the communicating filaments between the several ganglia of the chest cross the intercostal vessels. The *Splanchnic* nerves are great and small: the former arises by about five filaments from the thoracic ganglia between the sixth and tenth inclusive, which unite to form a single cord on either side of the body of the eleventh dorsal vertebra: this enters the abdomen by penetrating the corresponding crus of the diaphragm, and is usually separated from the aorta by a few muscular fibres. The small splanchnic nerve is similarly formed from the last two thoracic ganglia, or from the tenth and eleventh: it perforates the diaphragm external to the last.

The *Semilunar Ganglia* are a pair, and placed immediately below the diaphragm, resting on its crura, and against the aorta, close to the origin of the cœliac axis. They are equal in size to a horse-bean, the right being, with rare exceptions, the larger; the vena cava and renal capsule cover the right, and the pancreas and splenic vessels the left ganglion. Each ganglion receives the corresponding great splanchnic nerve, and the two are intimately connected by a network of thick filaments, to which the name of *Solar plexus* has been given. This plexus is of considerable extent: it lies upon the aorta, and receives communicating branches from the pneumogastric nerves. From this primary plexus the following secondary plexus are derived, viz., the phrenic, gastric, hepatic, splenic, superior, and inferior mesenteric. A separate account of these is unnecessary, as they are merely named according to the viscera they supply, and whither they are conducted by the appropriate arteries; they communicate more or less with each other and with the pneumogastric nerves.

The *Renal Plexus* is situated close to each renal artery, and receives the small splanchnic nerves and filaments from the semilunar and one or two of the



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lumbar ganglia; they give branches (*supra renal*) to the renal capsules, and others which accompany the vessels of the testicle (*spermatic*) to this organ, the secreting structure of which it is presumed they supply; in the female the ovary receives them. The principal portion of each renal plexus passes with the emulgent artery into the kidney.

The *Lumbar Ganglia* are five pair, similar in size to the thoracic: they lie on the anterior border of the psoas muscle at its attachment to the bodies of the lumbar vertebræ, being covered severally on the right and left sides by the vena cava and aorta. These ganglia communicate with each other, with the last thoracic and first sacral ganglia, and the anterior lumbar nerves: filaments also join the hypogastric plexus.

The *Sacral Ganglia* are usually four or five pairs, and are placed near the anterior sacral foramina: they communicate with each other and with their fellows, as also with the sacral nerves and last lumbar ganglion. The principal filaments form the *Hypogastric plexus*, in company with branches from the sciatic plexus: this network of nerves surrounds the internal iliac arteries, and accompanies its branches in their distribution to the pelvic viscera. A single ganglion is found on the coccyx (*ganglion impar*), which communicates with the last pair of sacral ganglia.*

Anatomy.

* For the physiology of this system the reader is referred to the Article 'Nervous Tissue, its Structure and Functions.'

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# ANATOMY.

## SECTION V.

### ORGANS OF DIGESTION.



In treating of the various organs by which the nutritious parts of the food are extracted and distributed over the system, and by which the exerementitious or refuse portion is separated and disposed of, the ensuing order will be followed as best adapted to a consistent view of the physiology of the assimilative system; the organs of Ingestion and Digestion, including both glandular and membranous chylopoietic viscera, will be first described; then the organs of Circulation and Respiration, with the Absorbent System; and, finally, the Urinary System. The anatomy of the organs of Generation will partly accompany and partly follow the last division of this extensive subject. It may be further premised, that the structural or minute anatomy and physiology of each system will succeed the description of the organs which constitute it, *i. e.*, wherever such detail has not been anticipated in an earlier part of the work; in which latter case the necessary references will be given.

*Mouth, Pharynx, Œsophagus.*—The food is received into the mouth for comminution and admixture with the saliva and mucus. This cavity, which may be described as of an ovoid form, is bounded above by the hard and soft palate, and below by the tongue; the teeth, strictly speaking, form the lateral and anterior boundaries of the oral *cavity*, when they are approximated and in contact with the surrounding soft parts; but as the vertical diameter of the mouth is subject to varied degrees of extension, according to the depression of the lower jaw, so likewise, under those circumstances, the lips and cheeks more directly assume their true relations of its lateral and anterior walls. The bony portion of the superior wall is composed of the palatine plates of the superior maxillary and palate bones, whilst the pendulous or soft palate presents a central depending process named the uvula, and a lateral production of mucous membrane which bifurcates above the tonsil, and is connected before and behind this bundle of glands to the side of the root of the tongue and the pharynx: these folds severally contain the muscles named palato-glossus and palato-pharyngeus. The cheeks and lips are composed of common integument (much loaded with fat in childhood and youth) externally, and of mucous membrane within: enclosed between these laminæ is the buccinator muscle on either side, and the muscles pertaining to the lips anteriorly. The position of the tonsils has been noticed: they consist of an aggregation of mucous follicles, with open mouths on either side of the isthmus faucium. The mucous membrane of the mouth is continuous with that of the pharynx and larynx.*

The various apertures or outlets which the mouth presents are the following: the anterior or labial, surrounded by the lips and their commissures; posteriorly, the isthmus of the fauces, surrounded by the palate above, the tongue below, and the fauceal pillars on either side; at the upper and back part of the cheeks, nearly opposite the upper second molar tooth of either side, is the opening of the parotid duct; also beneath the tongue, on either side of the frænum linguæ, are the openings of the ducts of the submaxillary and sublingual glands. The present would seem the proper place to describe these, the salivary glands.

The organs which secrete the *saliva* are placed symmetrically in pairs on either side of the face and neck. The largest is the *Parotid*, so named from its proximity to the ear; it occupies the interval between the vertical ramus of the lower jaw and external auditory canal, extending upwards as high as the Zygoma, downwards to a level with the angle of the jaw, backwards to the sterno-mastoid muscle, and forwards over the ramus of the jaw and masseter to a greater or less extent: its external surface is nearly flat, and thin towards its anterior margin; whilst, in its deep connexions, it is related to the vertical ramus of the jaw and auditory canal, the glenoid cavity and styloid process of the temporal bone, and capsule of the temporo-maxillary articulation; it lies upon the internal carotid artery, jugular vein, and eighth and ninth cerebral nerves. The external carotid artery bifurcates in the substance of this gland, which also contains the corresponding veins, the plexus of the facial nerve, and branches of the third division of the fifth cerebral, and of the cervical nerves. The Parotid, as likewise the other salivary glands, belongs to the class of conglomerate glands, and is enveloped in a dense fibrous tunic, which is derived from the cervical fascia, and which also invests the individual lobules of the gland: a strong process of fascia, named stylo-maxillary ligament, usually separates the parotid and sub-maxillary; but in some instances all the Salivary glands on one side form one continuous chain. The Duct of the Parotid (Steno's) springs from its anterior margin near its upper border; it crosses the masseter muscle horizontally, being usually accompanied by a process of the gland (*socia parotidis*), and penetrates the buccinator muscle and mucous membrane of the cheek very obliquely, to terminate as already noticed; the calibre of this duct is very small, but its walls are dense. The *Submaxillary* gland is intermediate in size between the Parotid and Sublingual: it is of an irregular spherical form, lying

* For the anatomy of the tongue and its muscles, as well as those of the palate, cheeks, and lips; and for the teeth, and especial anatomy of the mucous membrane, the reader is referred to the several heads, 'Senses,' 'Muscular System,' 'Osseous System,' 'Mucous Membrane.'



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under cover of the horizontal ramus of the jaw, and in the concavity formed by the curve of the digastric muscle: it is covered superficially by the platysma and cervical fascia, and rests on the mylo-hyoid and hyo-glossus muscles; having above and to its outer side the internal pterygoid muscle, and stylo-maxillary ligament, which separates it from the parotid; the lingual gustatory nerve lies above this gland, and the facial artery and vein penetrate its substance. The Duct of the Sub-maxillary gland (Wharton's) is much thinner, but of larger calibre, than that of the Parotid: it leaves the gland to wind above the mylo-hyoid muscle, and terminates, as already noticed, by the side of the frænum linguæ, its length being about two inches. The *Sublingual* is the smallest of these glands, and is placed near the median line, being separated from its fellow by the genio-hyo-glossi muscles alone; it lies close beneath the tongue, and in contact with the mucous membrane in this region: this small gland has several ducts which open beneath the tongue on either side of the frænum.

The *Pharynx* is the first part of the alimentary tube into which the food is received from the mouth. It is composed of muscle externally, and of mucous membrane within; and its extent is from the base of the skull to near the middle of the neck, where it terminates in the œsophagus. It is connected by its muscles (already described*) to the skull, face, tongue, and larynx; and its mucous membrane is continuous with that of the mouth. Its surrounding relations are, posteriorly, the cervical vertebræ and anterior spinal muscles, on which it rests; and laterally, the carotid sheath and its contents: its anterior wall may be said to be absent, where it communicates with the mouth and nasal fossæ. On either side of the last-named openings are the expanded orifices of the Eustachian tubes, which look forwards and inwards: behind the base of the tongue, and protected by the epiglottis, is the orifice of the glottis; and still further back and inferiorly is the œsophageal opening.

The *Œsophagus* is a continuation of the pharynx, communicating between it and the stomach. It commences about the fifth cervical vertebra, and takes nearly a vertical direction, deviating at first a little to the left of the median line, and again more abruptly so prior to its perforating the diaphragm. Its relations in the cervical region are, anteriorly the larynx, trachea, and thyroid body; posteriorly, the vertebræ and longus colli muscle; and laterally, the carotid sheath. In the thorax it lies between the trachea, left bronchus, and pericardium anteriorly; the bodies of the dorsal vertebræ, the aorta and thoracic duct behind, and the lungs on either side. The left vagus nerve is connected to its anterior, the right to its posterior surface. The muscular structure of the œsophagus is divisible into two laminæ, the external of which consists of longitudinal fibres; the deeper layer is composed of annular fibres, which are less dense than the superficial. The mucous lining of the œsophagus is continuous with that of the pharynx and stomach.† It may be here noticed that the ultimate constitution of the Pharyngeal and Œsophageal muscular fibres places them amongst those which are distinguished by transverse stripes, a character common to all the voluntary muscles: in many instances, however, it has been observed that the unstriped fibres are found, to the exclusion of the former, in the lower half of the œsophagus, or mingled with them to an uncertain extent.

*Abdomen.*—This large oval cavity, as it is called, is placed between the chest above and the pelvis below; the principal part of its parietes are soft and muscular. Posteriorly, it is bounded by the lumbar vertebræ, the crura of the diaphragm, the psoæ and quadrati lumborum muscles; anteriorly and laterally, by the abdominal muscles, properly so called; and above, the diaphragm forms the septum between it and the chest: inferiorly, the abdomen and pelvis are continuous, the plane of division corresponding to the margin of the latter. The contents of the abdomen are the chylopoietic and glandular urinary organs, together with the large vessels and nerves destined for their supply, or traversing the cavity to their destination. The different regions into which the abdomen is divided are indicated by imaginary lines stretching transversely and perpendicularly between the following points: the cartilage of ninth rib on either side; the anterior superior spine of either ilium; and vertical lines from the former two points to the latter. From this division nine spaces result, which have received the following names: in the median line above, the epigastrium, bounded laterally by the right and left hypochondriac regions; the central region is subdivided into umbilical and right and left lumbar regions; and the inferior division comprises the hypogastric and right and left iliac regions. Before describing the viscera individually it will be necessary to pay attention to the serous membrane which invests them.

The *Peritoneum* partakes of the character common to all the true serous membranes, viz., that of being a closed sac, and consisting of a reflected and investing or visceral portion. The use of the membrane, in this as in other instances, is to allow of a free gliding motion of the viscera, which are in contact with each other or with the parietes of the containing cavity; its surface is, therefore, highly polished and lubricated by its proper secretion. Some of the viscera are wholly covered by the peritoneum, and others only partially so; a condition which is regulated by the degree of mobility of the invested viscus: thus, the greater part of the membranous chylopoietic viscera are wholly enveloped in the serous membrane, whilst the more fixed and glandular viscera are in many instances only partially surrounded. The reflexion of the peritoneum is somewhat complicated by the existence of an inner sac or bag called the great omentum, which communicates with the general serous sac by a constricted orifice named the foramen of Winslow. In following the layer which forms the larger or external sac, it is found to line the anterior and lateral wall of the abdomen, and may be traced into the pelvis, where it is reflected over the summit of the bladder to its posterior aspect, and where a cul-de-sac exists between that viscus and the rectum in the male: in the female the uterus, Fallopian tubes, and ovaries are interposed between them, and receive an investment from the peritoneum, which descends for a considerable distance on the posterior aspect of the vagina. From the rectum the peritoneum spreads laterally into either iliac fossa, where it partially covers the cœcum and sygmoid flexure of the colon; and, passing back to the spine in

* See 'Muscular System, Pharyngeal Region.'

† For particulars respecting the mucous membrane in this and other regions, reference may be made to the head 'Mucous Membrane,' amongst the elementary tissues.

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the middle line, it forms the under surface of the root of the mesentery, and expands laterally into the lumbar regions to cover the right and left portions of the colon and surface of the kidneys, prior to becoming continuous with the parietal portion. From the spine the peritoneum is conducted by the vessels to the small intestines, which are entirely invested in this way, except the duodenum; and the membrane is then conducted back to the spine, above the vessels, to form the upper surface of the root of the mesentery. From this point the layer in question may be traced again descending to invest the transverse arch of the colon posteriorly, and to form the outer lamina of the great omentum: from the free border of this sac the peritoneum ascends loosely in front of the arch of the colon, and thence over the anterior surface of the stomach, the spleen, and upper part of the duodenum; it next lies upon the vessels passing between the stomach and liver, by which it is conducted to the latter organ, and is thence reflected over both its surfaces. In its passage from the convex surface of the liver to the diaphragm it is intercepted by the ligamentous remains of the umbilical vein, and thus forms the broad or suspensory ligament of this viscus: similar reflexions of the peritoneum from the posterior border of the liver are named the lateral ligaments, and likewise attach it to the diaphragm. Thus are the various parts of this great serous sac found to be continuous. It has been observed that the bag of the great omentum communicates with the general peritoneal cavity by a foramen: the position of this opening is behind the hepatic vessels, below the lobulus caudatus of the liver, and above the commencement of the duodenum; and from this constricted aperture the membrane is reflected in the following way. It descends in close connexion with the hepatic vessels, and is by them conducted to the posterior surface of the stomach, which it invests, and thence descends loosely over the transverse colon to the reflected margin of the omentum, which is generally lower on the left side than on the right. The posterior layer descends to meet that just described, crossing in its passage the middle and inferior divisions of the duodenum, the pancreas, the aorta, and vena cava ascendens. The several names given to various portions of the peritoneum included in the preceding description are the following:—the smaller omentum, enclosing the hepatic vessels; the gastro-splenic omentum, connecting the stomach and spleen; the transverse, right and left lumbar meso-colons, attaching the several divisions of the colon; the mesentery, connecting the small intestines to the spine; the meso-cæcum and meso-rectum, binding the cæcum and rectum to the right iliac fossa and sacrum.

The *Stomach* is the first and most dilated portion of the membranous digestive viscera in the abdomen: it communicates by its two extremities with the œsophagus and duodenum, and is liable to considerable alteration in size and form, as well as change of position, according to its degree of distension. In form, the stomach is conical and curved, so that it presents two surfaces, two curvatures and two extremities for examination: its greatest diameter is transverse. The anterior surface looks forwards and upwards, and is overlapped by the left lobe of the liver, whilst the posterior surface is less convex, and looks downwards and backwards: the greater curvature is convex, and faces forwards and downwards, corresponding to the transverse meso-colon: the smaller curvature is concave, and is directed backwards and upwards. The great or cardiac extremity of the stomach forms a cul-de-sac projecting beyond the œsophagus, and corresponding to the left hypochondriac region of the spleen: the smaller extremity, named the pyloric, is continuous with the commencing portion of the duodenum, and lies in the epigastric region. It has been remarked that the œsophagus pierces the diaphragm to the left of the median line: this opening is muscular, and is separated from the aortic aperture by the decussation of the crural fibres. This tube immediately afterwards terminates abruptly in the stomach, about one-third from its left extremity. The pyloric orifice is situated at the extreme right of the stomach, between the liver and pancreas, and immediately to the left of the gall-bladder: it presents a thickened feel to the touch, which is dependent on an annular arrangement of fibrous tissue between the muscular fibres, which are here aggregated in considerable quantity, and the mucous coat, which presents a reduplication, sometimes called the pyloric valve. Of the three tunics which constitute the stomach, the serous and mucous have been already described: the muscular coat is interposed between them, being pale in colour, and arranged in three laminæ. The superficial layer is continuous with the external œsophageal fibres, and exhibits a longitudinal arrangement, which is most apparent along the curvatures: the annular fibres lie immediately beneath these, and are most distinct in the middle and towards the small extremity: lastly, beneath the circular, there is an irregular layer of oblique fibres, which are found extending over the surfaces and great extremity of the Stomach. A dense layer of cellular tissue connects the muscular and mucous coats.



The *Small Intestine* is divided into three portions, severally named Duodenum, Jejunum, and Ileum. The first division, or *Duodenum*, is short, large, and fixed in position, though capable of considerable distension. In its course it describes a curve which extends from the pylorus to the root of the mesentery, and which encloses the head of the pancreas. The commencement of this curve is called the superior transverse portion, which is directed backwards and to the right side, and lies in the right hypochondriac region: the central portion takes a vertical direction downwards in front of the right kidney and vena cava, and therefore lies in the right lumbar region; having attained its lowest point, the intestine now proceeds upwards and to the left side, in front of the aorta and behind the superior mesenteric artery, to terminate in the jejunum: this division is called its inferior transverse portion. The duodenum, in the above course, extends over a space corresponding to the first three lumbar vertebræ: its superior abrupt turn corresponds to the under surface of the liver and neck of the gall-bladder, with the bile from which it is usually found tinged after death: the common gall-duct and that from the pancreas perforate the intestine obliquely, and open close together or by a common aperture at its lowest point. The serous investment of the duodenum has been already described as completely surrounding its superior division, and only covering the anterior surface of its remainder; from which arrangement it results that the superior transverse portion is the most moveable. Its muscular coat consists almost exclusively of annular fibres, which are strong and distinct. The mucous coat presents an

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abundance of those prominent folds named valvulæ conniventes, which project into the interior of the intestine, and are arranged in the form of arches or segments of circles. A prominent papilla marks the point of entrance of the ducts already alluded to; and the obliquity of their perforation is probably a sufficient protection against the risk of regurgitation from the intestine.

The *Jejunum* commences at the termination of the duodenum, and the *Ileum* terminates abruptly in the cul-de-sac by which the large intestine commences. The distinction between the lower two divisions of the small intestine is purely arbitrary, two-fifths being assigned to the former and three-fifths to the latter; the distinguishing characteristics of the extremities of each being blended in the interval. The jejunum and ileum occupy the umbilical, hypogastric, and part of the iliac, lumbar, and pelvic regions; but as their convolutions are perfectly free and moveable, the extent of space they occupy of course varies according to their degree of distension: the great omentum forms a sort of apron which descends in front of them, and in fat people quite conceals them. These divisions of the alimentary tube are smaller than any other part, and, taken as a whole, it slightly diminishes in size as the cœcum is approached. The most fixed points are the commencement of the jejunum and termination of the ileum, which latter is situated in the right iliac fossa. It has been said that these intestines are surrounded by peritoneum, unless indeed the line of reflection of the serous membrane be excepted: the mobility of these viscera is further secured by the length of the mesentery between the spine and intestine: it may be also remarked, that the two laminæ which form this division of the peritoneum enclose the mesenteric glands and vessels, and conduct the arteries, veins, and lacteals to and from the intestine. The muscular coat of the jejunum and ileum consists of a double layer of pale weak fibres; the external being longitudinal and most distinct on their convex border, and the internal annular, but irregular and interrupted. The mucous coat is pale, and exhibits an abundance of valvulæ conniventes at the commencement of the jejunum, but the lower part of the ileum is destitute of them.

The *Large Intestine* is divided likewise into three portions named Cœcum, Colon, and Rectum. The *Cœcum* occupies the right iliac fossa, and presents the appearance of a large bulging cul-de-sac, in the left side of which the ileum abruptly terminates, and from the superior part of which the commencement of the colon ascends. It is bound in its position by a reduplication of the peritoneum, which surrounds it more or less in different subjects, and attaches it to the iliacus and psoas muscles: superficially, it is in contact with the anterior abdominal parietes. From its lower and back part hangs a cylindrical closed process, called *appendix vermiformis*, which is about the size of a goose-quill, and three or four inches in length: it communicates with the interior of the cœcum. The exterior of this intestine is marked by three longitudinal depressions, which commence from the point of attachment of the vermiform appendage; and other annular constrictions throw it into folds so as to give it a sacculated character: several small appendages of the peritoneum, containing fat, are also seen on its surface; they are the appendices epiploicæ. The muscular coat of the cœcum consists of longitudinal and annular fibres: the former are collected, as already noticed, into three bands, which, from their relative shortness, give rise to the sacculated character just alluded to. The mucous membrane is evenly disposed over the interior of the cœcum, but presents a remarkable reduplication at the point of entrance of the ileum: this, the ilio-cœcal valve, results from the folding of the mucous membrane of the small intestine which projects into the cœcum, and thus consists of two lips, which are so placed in relation to each other as to present a transverse fissure when the intestine is distended and dried: the extremities of these lips are connected by commissures. By the above arrangement regurgitation of the contents of the cœcum or colon is prevented.



The *Colon* is divided into four portions. The ascending division lies in the right lumbar region, in front of the quadratus lumborum muscle and right kidney, and more or less concealed by the folds of the small intestine: its superior extremity touches the under surface of the right lobe of the liver and gall-bladder. From the last-mentioned point the arch or transverse portion of the colon proceeds from right to left, crossing the epigastric region below the stomach and above the small intestines, and covered anteriorly by three of the four laminæ composing the great omentum: its termination is somewhat higher than its commencement, being placed in the left hypochondrium, and closely approximated to the spleen. The descending colon is a continuation of the same intestine through the left lumbar region to the iliac region of the same side, where the sygmoid flexure is attached: each of these divisions holds relations analogous to the corresponding portions of the opposite side. The connexions of the sygmoid flexure are sufficiently loose to allow it to expand more or less into the pelvis: it derives its name from the double turn it forms, and terminates just above the left sacro-iliac articulation in the rectum. Of the four divisions of the colon the arch is the most capacious, and the ascending division rather the smallest. The appendices epiploicæ are scattered over the different portions, and are especially numerous on the arch. Each division is to a certain extent confined in its position by its peritoneal investment: the sygmoid flexure is the most moveable. The muscular and mucous coats present a similar character and arrangement to that already described in the cœcum.

The *Rectum* extends from the termination of the colon to the anus, taking first an oblique course, and then descending in the median line. This intestine presents a curvature corresponding to that of the sacrum, against which it lies; but it subsequently bends forwards to obtain a position anterior to the coccyx before it dips down to terminate in the anus. The anterior relations of the rectum differ in the male and female; but in both a cul-de-sac of peritoneum is found immediately in front of the intestine above. Below, in the male, the rectum corresponds to the vesiculæ seminales, prostate gland, and lower fundus of the bladder; but in the female it is related to the posterior surface of the vagina: the upper fundus of the bladder in the male, and the uterus in the female, correspond to the superior anterior part of the rectum. As regards calibre, this portion of the great intestine is somewhat smaller than the colon, but is capable of considerable distension: a permanent dilatation exists near its inferior extremity. The rectum is fixed in its position by the meso-rectal fold of peritoneum. Its muscular coat is distinct and dense: the superficial fibres are longitudi-

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Anatomy. nal, and especially developed in the two upper thirds; whereas the annular fibres which constitute the deeper layer are more developed near the anus. The levatores and sphincter ani also enclose the lower part of the gut. The mucous membrane presents no character, save that of increased vascularity, by which it can be distinguished from that of the colon.

A microscopical examination of the elementary muscular fibre of the membranous digestive viscera proves that both laminæ throughout consist exclusively of the unstriped fibres common to most of the involuntary muscles: the sphincter ani consists of striped fibres. The average length of the human intestinal canal may be stated at about thirty feet, of which the large intestine constitutes one-fifth.

The *Liver* is the largest of the glandular viscera connected with digestion. It is of a reddish brown colour, and occupies the right hypochondriac and upper part of the epigastric regions. Its extent, size, and form vary slightly in different individuals, independently of marked changes. The superior surface is convex, and corresponds to the diaphragm, which it presses upwards so as to encroach upon the right side of the thorax; the inferior surface is irregularly concave, and presents a horizontal fissure or groove which corresponds to the line of reflection of the suspensory ligament above: this lodges the remains of the umbilical vein, and divides the liver into two unequal lobes, the right and left. Extending from the horizontal fissure, transversely to the right, is the porta or transverse fissure, in which lie the hepatic vessels; and behind the porta is the third lobe, or lobulus Spigelii, which occupies a position between the vena cava and œsophagus, and is connected to the right lobe by two processes: one of these is thick, and placed transversely. The groove in which the vena cava is lodged is between the right and spigelian lobes; and in the same line, but anterior to the porta, is the depression for the gall-bladder: the under surface of the right lobe is further marked by shallow depressions, corresponding to the right kidney and right angle of the colon. The under surface of the left lobe is concave, and corresponds to the upper and anterior surface of the stomach. The posterior margin of the liver is thick, obtuse, and rounded, especially towards the right side, and presents a deep notch corresponding to the bodies of the vertebræ; the anterior is thin, and is marked by an abrupt notch opposite the horizontal fissure at which the umbilical vein becomes attached to the liver. The lateral edge of the right lobe is thick, but that of the left is gradually bevelled and thin. The *Gall-bladder* is in shape pyriform, and occupies the position already indicated, generally extending beyond the margin of the right lobe, which presents a broad and sometimes deep notch at the point in question. The upper surface of this membranous viscus is in close connexion with the texture of the liver, to which it is bound by a superficial covering of peritoneum: its narrowest portion or neck is directed backwards and towards the left side, and terminates gradually in the cystic duct, which joins the common hepatic duct at an acute angle to form the ductus communis choledochus. Independently of the serous covering already described, the liver has a proper investment of its own, which is of a condensed cellular nature, covering its whole surface, and reflected around the vessels at the porta, so as to pass with them (under the name of Glisson's capsule) into its interior. The interior of the gall-bladder consists of soft and thick mucous membrane, connected by cellular tissue to the serous envelope and liver. The vessels which enter the liver are the hepatic artery for its nourishment, and the vena portæ for the secretion of bile: the hepatic duct is formed by the junction of a branch from either lateral lobe, and also leaves the porta: the venæ cavæ hepaticæ return the venous blood to the vena cava ascendens. Anatomy.

The investigations of Mr. Kiernan* have clearly demonstrated the following facts in connexion with the minute anatomy of the liver: the subjoined is a brief abstract of his description. The liver presents three *surfaces*—the external (already considered); the portal, containing the vena portæ, hepatic artery, and hepatic duct; and the hepatic venous surface, containing the vena cavæ hepaticæ. The *substance* of the liver is made up of lobules, vessels, nerves, and cellular tissue. The lobules are based, like leaves without footstalks, on the hepatic veins; and the interspaces between them are named the interlobular fissures. Four sets of *vessels* ramify in the interior of the liver:—1. *Hepatic veins*, the larger branches of which are called hepatic venous trunks, and the smaller the sub-lobular branches, being those on which the lobules rest. From these last, perforating twigs are given off, which enter the lobules and are thence named intra-lobular: between these ultimate branches there is no communication. 2. *Hepatic artery*, ramifies on the vessels and other textures of the liver for their nourishment, and then terminates in the portal system, thus aiding indirectly in the secretion of bile. 3. *Vena portæ*, the destination of which is to the spaces and fissures between the lobules, where they give off branches which penetrate into the interior of the lobules, where they ramify towards the centre: the larger branches between the lobules are named inter-lobular veins, and those which circulate in the lobules are the lobular venous plexuses: these last meet and anastomose with the intra-lobular plexuses of the hepatic veins: the inter-lobular branches of the porta also communicate freely with each other. 4. *Hepatic duct*, the ramifications of which accompany the inter-lobular branches of the portal vein, to carry away the bile when secreted. Where the ultimate twigs of the two last-named vessels terminate, minute yellow points are perceptible: these are the acini of Malpighi. The cellular investment of the vessels, called *Glisson's capsule*, accompanies the vessels which enter the porta, and proceeds with them to their destination, so as even to form a capsule to the lobules. Either of the above sets of vessels may become congested separately, giving rise to different colours and to varying relative density; a fact which Mr. Kiernan notices as a prolific source of error in the descriptions of previous anatomists.

The *Pancreas* is an elongated conglomerate gland, of a greyish colour, and essentially the same in character and structure as the salivary glands. Its long axis is transverse, and it is stretched somewhat obliquely across the spine, about opposite the second lumbar vertebra, its right extremity being lower than the left. The length of the pancreas is about seven inches, but it varies in size and weight. Its anterior surface corresponds to the stomach, and it is covered by the ascending layer of the transverse meso-colon; poste-

* *Philos. Transact. for* 1833. Part 2.



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riorly it is in contact with the left crus of the diaphragm, vena cava, and aorta. Its left extremity is small and approximated to the spleen; but the right is larger, is named the head, and lies in the curvature of the duodenum: the upper and back part of the gland is grooved to lodge the splenic artery and vein. Frequently a detached portion of the gland lies beneath the head, and is thence called smaller pancreas. The excretory duct is pale and thin, and placed somewhat nearer the posterior than the anterior aspect of the gland: it extends from left to right, increasing in size as it collects the radicle branches from the surrounding lobes, and emerges at the head to join the ductus communis choledochus at an acute angle. The two ducts terminate, as already noticed, either conjointly or near together, in the duodenum.

The *Spleen* is usually enumerated amongst the glands of the abdomen, though its title to this appellation seems more than questionable. It occupies the deepest part of the left hypochondrium, being connected to the great extremity of the stomach by the gastro-splenic omentum: its upper and outer surface is convex, and corresponds to the diaphragm; below, it overlaps the upper part of the left kidney and supra-renal capsule: internally, it is fissured for the transmission of the vessels; and posteriorly, it rests to the left of the spine. The colour of the spleen is purple, its texture spongy, and it is very vascular. It is supplied with a fibrous investment which sends processes into its interior. On minutely examining the structure of the Spleen, it is found to present spaces which are bounded by the reticulated substance of the organ; these are venous canals, which, when injected, appear similar in character to those of the corpora cavernosa penis: there are no true cells. The red pulpy substance consists of granules, about the size of blood corpuscles, but globular. Malpighi further discovered in this substance whitish globules visible to the naked eye: these are difficult to detect in the human spleen. This organ has no excretory duct.

### Physiology of Digestion.

Convenience has determined that nourishment should be conveyed into the circulating system of both animals and vegetables in a fluid form; but for the most part solid food is the support of animal life, and hence the difference and contrast in the assimilating apparatus of the two divisions of the organic kingdom. Thus a complex provision is requisite for the reduction of animal food prior to its being absorbed by the lacteal vessels from the alimentary canal; whereas the roots of plants, which are the analogues of the lacteals in animals, directly absorb the prepared aliment from the matrix in which they are lodged. The further processes of circulation and aerification are similar in the two kingdoms, but at the same time present one remarkable and interesting contrast, which is all-important in the preservation of both animal and vegetable life, viz., the mutual interchange of gases in respiration, which operates both negatively and positively in effecting the desired end.

In tracing the progress of the food, and following the same course as that which has been pursued in the anatomical section, the mouth first presents itself for consideration. The *lips* exhibit varied forms and degrees of development, according to the functions required of them in different classes of animals: thus their greater mobility and relative development in some graminivorous animals is connected with their use in collecting their food,—a peculiarity which is much exaggerated in some species, and arrives at its maximum in the elephant, in which animal the remarkable production of the upper lip (the proboscis), and its great power and flexibility, enable its possessor to select the herbage indiscriminately from the earth on which it treads, or from the trees of the forest which it frequents. In man, though the lips are serviceable in the acts of mastication, their peculiar organization and great mobility are rather associated with the more exalted office of the articulation of sound and production of language. The *Comminution* of the food is effected in various ways, according to the nature of the aliment and habits of different animals. Three modes of reducing solid food may be enumerated: trituration, as in man; laceration, as in birds of prey; and by the gizzard, as in the granivorous birds. In mammalia, the titles "carnivorous" and "graminivorous" are assigned to animals whose natural food is exclusively animal or vegetable; and each class is characterized by corresponding development of the organs of comminution. In the carnivora the *jaws* are massive and present a simple hinge arrangement, whilst provision for great lateral motion is made in the construction of the jaws in vegetable feeders; there is also a corresponding relative development in the prehensile and grinding muscles. The *teeth* also, as might be anticipated, present a remarkable contrast in animals whose habits are so different: thus, the compressed crowns and pointed processes of the grinders, the lower closing within the upper, are peculiarly fitted for the office of lacerating flesh; whilst, on the other hand, the expanded, oblique, and permanently uneven surface of the corresponding teeth in the graminivora (especially the ruminants) are equally adapted for the grinding of vegetable matter: indeed, the analogy of the scissors and mill-stone, as applied to the forms of mechanism above alluded to, is not inapt. The mixed development of both the jaws and muscles, and of the teeth, in man, point him out as partaking of the characters of both classes of animals above alluded to: his moderate incisors and small canines, his expanded molars, and the lateral motion of the lower jaw, indicate that he is omnivorous, or destined to be nourished by a mixed animal and vegetable aliment. The integrity of the teeth is essential to the prolonged existence of animals, and usually determines that existence when its period has not been curtailed by some of the countless risks to which all creatures living in a state of nature are subjected: thus, when deprived of teeth, the graminivorous animal starves, and the predacious in turn falls a prey to others.*

The uses of the *cheeks* and *tongue*, as connected with mastication, have already been cursorily alluded to: by these organs the food is pressed on either side, so as to keep it between the teeth during the act of trituration: the tongue further conveys the food into the pharynx. Before leaving the mouth the bolus has to be moistened by the various secretions of the *buccal*, *salivary*, and *tonsil* glands. The mucous membrane of

* For further details on the development of the teeth in different animals, the reader is referred to the 'Comparative Anatomy of the Osseous System.'

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the cheeks, lips, and tongue are supplied liberally with secreting follicles, which give out their secretion during the act of trituration. Further, the position of the salivary glands is such as to subject them to the action of the muscles of mastication, by which means they are mechanically stimulated to pour forth saliva, as occasion requires, in increased abundance: dry food, acids, &c., also excite a flow of this secretion, which likewise appears, in common with some other secretions, to be considerably influenced by mental emotions: thus the remembrance of agreeable food is proverbially said to "make the mouth water;" and the parched mouth, from suspension of this secretion, is no less characteristic of deep grief or paralyzing terror. The burning thirst of fever and impairment of the sense of taste also seem to be principally referable to the suppression of the salivary secretion. The saliva, according to Berzelius, contains about one per cent. of solid ingredients: the following is his analysis:

| | |
|---|---|
| Water | 992·9 |
| Peculiar animal matter | 2·9 |
| Mucus | 1·4 |
| Alkaline muriates | 1·7 |
| Lactate of soda and animal matter | 0·9 |
| Pure soda | 0·2 |
| | 1000·0 |

When duly moistened, the bolus of food is placed on the surface of the tongue near to its base, and by it pressed backwards between the pillars of the fauces (where it is further lubricated by the tonsillitic secretion) into the expanded pharynx; this act, however, requires further consideration. *Deglutition* is partly effected by voluntary muscles, and in part by muscular contraction, altogether independent of the will; indeed, the various stages which compose the act, with the exception of the backward pressure of the tongue, are so far under the control of the excito-motory system, that without the necessary stimulus of the presence of food the effort cannot be completed. The true agency of the soft palate and its muscles has but recently been explained by Dzondi, in his dissertation on the subject.* Previous to this writer's description it was generally assumed by physiologists that food was prevented from entering the posterior nares by the soft palate being thrown back and raised; but Dzondi has clearly shown that when the food is placed within the grasp of the palato-glossi muscles, they, in their turn, contract and force the bolus onwards into the pharynx; but, simultaneously with this second act, the glottis and epiglottis are approximated to each other by the twofold operation of the retro-pressure of the tongue and uplifting of the larynx, by which means, and the closure of the rima glottidis, the air-tube is effectually protected; and also the palate is fixed by the action of its tensor muscles, so as to enable the palato-pharyngei muscles to contract and close the isthmus of the fauces by the approximation of the sides of the posterior palatine arch; and the angular interval which is left above is occupied by the uvula. The self-same act by which the communication with the posterior nares is shut off aids in raising the pharynx to receive the food. The remainder of the act of deglutition consists in the alternate contraction of the pharyngeal muscles, and the peristaltic or undulatory contraction of the œsophagus, by which their contents are forced onwards to the stomach. That this the last stage of swallowing is essentially a muscular act, is illustrated by the mode in which a horse drinks, the fluid rising to the stomach against gravity. In pursuing the changes which the food undergoes in the stomach and alimentary canal prior to entering the circulating system, it will be inconsistent with the limits of the present article to encumber the subject of human digestion with illustrations drawn from a comparison of the structure and functions of the assimilating apparatus in various classes of animals with those of man; suffice it to observe that the modifications, in development and office, go hand in hand; that where the food possesses qualities which are remote from those of the matter into which they are to be ultimately converted, and the loss of which they are to supply in the animal frame, the organs of digestion are correspondingly complex; but that where identity in the properties of the aliment and the frame to be nourished exists, they are comparatively simple. A comparison between the membranous chylopoietic viscera of flesh and vegetable feeders affords an ample illustration of the above assertion.

The *Stomach* in Man is principally a secreting organ; but it also aids in the digestive process by its muscular contractions. It has been observed that the stomach presents two orifices,—the Cardiac or œsophageal, and the Pyloric or intestinal; each of these is guarded by a muscular ring,—that of the former being the circular œsophageal fibres and the fleshy opening in the diaphragm, and that of the latter the annular fibres of the pylorus: this arrangement is essential to prevent the escape of food from the stomach during the act of digestion. The size of the cardiac orifice varies much in different animals: in the dog it is large, and readily admits of the regurgitation of the food; whereas it is contracted in the horse. In ruminant animals, the facility with which the food is returned to the mouth is greatly aided by the muscular development of the œsophagus. In connexion with the present division of the subject, it will be requisite to insert a few observations in relation to the act of vomiting. The question whether the stomach takes any active part in rejecting its contents has been often discussed, and been made the subject of experiment, with varied results. There is but little doubt in the writer's mind that, though the parietal compression is generally the most efficient agent, the antiperistaltic action of the stomach and œsophagus always co-operates, and may, even unaided, reject the food. The following appear to be the different preliminaries and conditions which constitute the act of vomiting. A deep inspiration is taken, by which the chest is distended and the diaphragm pressed against the abdominal viscera; the glottis is then closed to preserve the above condition; the abdominal muscles are now called into action, and the stomach compressed between them and the fixed diaphragm, so as to be forced to part with its contents. In this last stage of the act there is no interference on the part of the muscular opening in the diaphragm; for the active contraction of that muscle is superseded by the closure of the glottis, and consequent passive distension of the thorax. Here also the important office fulfilled by the muscular ring of the diaphragm in relation to the stomach may be indicated, viz., the protection it affords

* *Ueber die Functionen des Weichen Gaumens.* Halle, 1831.



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to this viscus when distended during the acts of inspiration; the contraction of the fibres around the œsophagus concurring with the action of the whole muscle, and thus presenting an obstacle to regurgitation, where the stomach is most subjected to compression by the descent of the diaphragm. The muscular movements of the stomach appear to be under the control of the sympathetic system.

In the Stomach the food has to be subjected to the action of the gastric juice; and the peristaltic movements of the viscus subserve the purpose of bringing different portions of its contents into contact with its surface, and therefore under the more direct agency of the solvent fluid. The qualities and even the existence of the gastric juice was, for a long period, a subject of controversy with physiologists; and it is chiefly to the comparatively recent experiments of Dr. Beaumont, which a happy chance enabled him to make, that we are indebted for our present definite information upon the subject. The observations alluded to are valuable and interesting, being the result of direct experiment upon an individual named St. Martin, in whom a fistulous opening below the left mamma, and communicating with the stomach, remained after a gun-shot wound.* The difficulty of ascertaining the essential constituents of the gastric secretion depends on the obstacles offered to obtaining it in a pure and unmixed state, owing to its suppression during the intervals between the periods of digestion. The most apparent properties appear to be the following:—1. It is decidedly acid; for the digested food taken from the stomach is found to yield acids which are not the product of fermentation: 2. It does not promote putrefaction, but on the contrary possesses antiseptic properties, as proved by repeated experiments. It may be further remarked, that the solvent quality of this secretion bears an inverse proportion to the muscular strength of the stomach. The conflicting opinions which were maintained regarding the acid qualities of the gastric juice appear to have had their origin in the difference of period selected for the examination of this fluid; and it is to the accurate researches of Tiedemann and Gmelin that we were first indebted for a clear exposition of the sources of fallacy. The results of their experiments establish the fact, that both in vegetable and animal feeders (horse and dog) the gastric secretion was nearly neutral when the stomach was void; but that decidedly acid qualities were developed as soon as food was introduced, or even mechanical irritation employed. Dr. Beaumont's observations enable him to state, that in his patient the gastric juice was poured out over the surface of the stomach at various points, which appear to be simple follicles of the mucous membrane. He describes it as a transparent fluid, devoid of odour, slightly saline, and very perceptibly acid: and when subjected to analysis from the same source, it was found to contain free muriatic acid, acetic acid, phosphate and muriate of potash, soda, lime, and magnesia, and an animal matter soluble in cold water. That the solvent power of the stomach resides in the gastric juice, has been amply verified by the experiments of the same observer, who obtained from the source already mentioned, by mechanical irritation of the stomach, sufficient of the fluid to enable him to watch the process of digestion. The general result of these experiments was, that the fluid thus obtained was capable of completing digestion out of the body as perfectly, although more tardily, as in the natural way: it was necessary to preserve a temperature approaching 100° Fahrenheit, to ensure the success of the experiment: for when the fluid was permitted to cool, digestion was almost or entirely suspended. Satisfactory as the above results may appear, and easy as would seem to be the transition to purely artificial digestion, still experimenters failed in producing solution of animal matter by any artificially prepared fluid. The cause of this failure and the compound character of the solvent have been clearly demonstrated by the discoveries of Eberle, to which those of Schwann and Müller may be added. The first of these physiologists showed, in a paper which he published on the subject,* that the true solvent consists of an admixture of acid with mucus, although either separately is inert. He further asserted, that mucus procured from any other source was equally efficient with that obtained from the stomach; but this has been denied by Schwann and Müller, who found that no such substitute for the gastric mucus was admissible. The experiment, as detailed by Müller, is very easily performed by placing in a test-tube or any convenient vessel some small pieces of dried mucous membrane of the stomach, in an admixture of an ounce of distilled water, with a few drops of muriatic or acetic acid: to these a piece of hard-boiled white of egg is to be added, and a temperature of about 100° Fahrenheit maintained: in the course of twenty-four hours the solution of the albumen is usually complete. Further, the experiments of Schwann prove what might have been anticipated,—that an infusion of mucuous membrane with dilute acid, when filtered so as to be deprived of all solid particles, still possesses its solvent property. The preceding remarks are not found equally applicable to all articles of food; for whilst animal fibre and coagulated albumen are soluble in this compound fluid, which Schwann calls *pepsin*, he states that gelatin, casein, and vegetable gluten are not so, but are dissolved principally by the acids.† Various experiments have been instituted to prove the influence of the nervous system in digestion; and the most trustworthy of them seem to indicate that the pneumogastric nerves are importantly associated with the secretion of the digestive fluid. The division of this pair, which was followed by death at different intervals, appeared to suspend entirely, or almost so, the solution of the food. These results, however, have not been obtained by other physiologists; and it must be acknowledged that the present appears to be an exception to the prevailing relation between the sympathetic system of nerves and secretion; and one can scarcely wonder that such a mutilation as that above described should be succeeded by impaired or even suspended digestion, where death is inevitably entailed, in quadrupeds after a few hours, and in birds after the lapse of a few days at furthest. The experiments of Dr. W. Philip, which he considered to prove that the arrested function was restored by a current of electricity directed through the divided nerves to the stomach, have not succeeded in the hands of others.

* *Experiments and Observations on the Gastric Juice, &c.* By W. Beaumont. Boston, 1834.

* *Physiologie der Verdauung.* 1834.

† For further particulars the reader may consult Müller's *Physiologie*, p. 517, &c.; or Schwann's original papers in Müller's *Archiv*, for 1836.

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 The whole contents of the stomach are not submitted at once and simultaneously to the agency of the gastric fluid, but the process is aided in the following way by muscular action, according to the observations of Magendie. When a meal has been taken, the stomach is closely applied around its contents, and the periodical peristaltic motions are usually observed to commence a little beyond the pylorus, and to extend across it to the large extremity: an interval then occurs, which is succeeded by contraction, extending through the pyloric half of the stomach towards the duodenum, such portions of the contents as are prepared being transmitted by the pylorus into the intestine. A succession of these motions is repeated several times, and then a longer interval of rest succeeds: and it appears that the splenic extremity of the organ takes but little, if any, part in these undulatory movements until the greater part of the contents are digested and got rid of. We may infer, from these observations of M. Magendie (which have been confirmed by Beaumont and others), that a circular motion is given to the food along the two curvatures of the stomach, by which different layers are submitted in succession to the continually secreted gastric juice, until all is dissolved, or converted into *Chyme*, which is permitted to pass into the duodenum by the relaxed pylorus: in the earlier periods of digestion, the contraction of the annular muscle at this part of the stomach is such as even to arrest the transmission of liquids. It is the opinion of M. Magendie that fluids are directly absorbed from the stomach: but observation has proved that in some animals, as the horse, water rapidly finds its way even to the cœcum. It may be here remarked, that dilution of the gastric juice materially curtails, or, if copious, even destroys, its solvent property; a circumstance which should be particularly impressed by the practitioner of medicine on his dyspeptic patient, and which no one should be ignorant of. Some interesting tables of the relative digestibility of different kinds of food are given by Dr. Beaumont in his paper already quoted: the general result proves that in man animal substances are more quickly digested than vegetables. It may be also inferred, from the observations made above, that articles of diet which are not readily permeable by the gastric fluid (such as new bread or hard dumplings), must, from this mechanical obstruction, be more difficult of digestion than those which are more readily saturated. The observations of Marcet, Prout, and others, show that the constituents of the chyme vary according to the nature of the food: the principal are albumen, a substance resembling casein, and osmazome, mingled with the various secretions which have been enumerated. It may be further remarked, that in dogs the chyme contains more albumen when the diet consists of animal substances.

The next stage of digestion takes place in the duodenum, and consists of the conversion of the chyme into chyle: and this will involve some preliminary notice of the functions of the liver, pancreas, and spleen. The importance of the *Liver*, as subservient to digestion, is attested by the almost universal presence of this organ, even amongst the lowest animals. It is of large size in amphibia and in domestic animals; and does not uniformly present the even exterior which exists in man, but it is deeply grooved in some of the carnivora, as the lion,—a character which has been supposed to be connected with the violent and distorted movements of the body in these animals. The researches of Mr. Kiernan confirm the opinion which has been generally entertained, that the biliary secretion takes place from the capillary terminations of the vena portæ. It is true that the secretion has not been wholly arrested by ligature of the vena portæ; but this objection is met by the anatomical fact clearly established by Mr. Kiernan, that the hepatic artery ultimately pours its blood into the portal system: and even where the vena portæ has been known to terminate in the ascending cava, of which there are cases recorded by Mr. Abernethy and Mr. Lawrence, it seems probable that the internal arrangement of the blood-vessels involved the conversion of the arterial into venous blood before the separation of the bile took place. The several functions of the vessels which circulate blood in the liver may be thus stated: the hepatic artery is the nutrient vessel; the vena portæ the secreting vessel; and the venæ hepaticæ are the returning vessels of the blood. The bile, as already stated, is conveyed to the duodenum by the biliary ducts. The physical properties of the *Bile* are, that it is of a yellowish-green colour, bitter in taste, and of a faint disagreeable smell. Its re-action is decidedly alkaline; and it is much more viscid and deeper in colour after remaining for some time in the *gall-bladder*; a condition which appears to depend on the absorption of its more fluid part. This membranous viscus is not an invariable appendage of the liver, but is present, according to Cuvier, in those animals which take their food at long intervals and in large quantities, as the carnivora; whilst those of the horse and goat kind want it: the ruminantia possess it. It has been observed, that the quantity of bile contained in the gall-bladder varies, being considerably more abundant prior to digestion than subsequent to its completion. We may therefore infer that this viscus has the twofold function of acting as a reservoir and filterer of the bile. The various analyses which have been made of the bile do not present very consistent results, which Berzelius attributes to the tendency to decomposition which he considers certain simple substances it contains to have: that which Gmelin and Thenard describe under the titles of picromel and biliary resin, Berzelius calls biliary matter. According to Müller, the bile contains grey particles, which in the frog be found five times smaller than the red corpuscles of the blood.* The following is the analysis of ox bile, as given by Berzelius in his *Animal Chemistry*.

| | |
|---|---|
| Water | 90·44 |
| Biliary matter, with fat | 8.00 |
| Mucus (from gall-bladder) | ·30 |
| Osmazome—chloride of sodium, and lactate of soda | ·74 |
| Soda | ·41 |
| Phosphate of soda and of lime, with a substance insoluble in alcohol | ·11 |
| | 100·00 |

The *Pancreas* is by no means so universal an organ as the liver, being confined almost exclusively to the vertebrate class, and not present in many fishes. Moreover, experiment has proved that it is not essential to

* Müller's *Physiology*, vol. i., p. 502.

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digestion, as the gland has been removed in animals without producing any marked effect. The position of the Pancreas renders it difficult to obtain the secretion; but this has been done by Tiedemann and Gmelin, who collected the fluid by the insertion of a tube into the duct. Their account of it is, that it is clear and ropy, slightly saline to the taste, and containing albumen in considerable quantity: also some osmazome, and a substance like casein; and free acid (probably acetic) in very small quantity; the great bulk of the secretion being water. Other experimenters mention having met with the salts of soda, potash, and lime in it: it differs further from the saliva in containing no sulpho-cyanic acid.

The *Spleen* is almost universal amongst vertebrata, and confined to them. Its structure and organization have been already described. The hypotheses which have been broached respecting the function of this viscus have been numerous, and many of them as ill-founded as the premises and experiments which led to the conclusions were erroneous and ill conducted. Its proximity to the stomach have naturally induced physiologists to associate it in function with that organ: hence it has been supposed to act the part of a reservoir for the blood when the stomach was empty; and that the replete condition of the latter forced the blood from the spleen by compression. An eminent physiologist recently taught that it acted as a reservoir under violent exertion, and stated that the bile underwent no chemical change after its removal. These mechanical uses, and the absurd impression that it operates as a counterpoise to the liver, are probably quite insufficient explanations of its real use: and although some part may be assigned to it in the preparation of the venous blood for the secretion of bile, one would more readily coincide with Müller, who supposes that the spleen is connected with sanguification, and influences the blood which passes through it in some way which is not at present understood: this physiologist further thinks it may be employed in the secretion of a peculiar lymph; as Hewson supposed it formed the vesicular portion of the blood corpuscles.

In order to test the influence of the bile in digestion, experiments were instituted a long while since by Brodie, the results of which have been confirmed in many particulars by those of Tiedemann and Gmelin. Obliteration of the ductus choledochus was invariably followed by jaundice, which continued until the death of the animal, which usually occurred at the expiration of two or three weeks: in a few instances recovery followed the re-establishment of the obliterated canal. The process of digestion in the stomach, that is, the production of chyme, was in no way interfered with: but according to Brodie, the further change into chyle did not take place. The experiments of Tiedemann and Gmelin led them to an opposite conclusion in this last important particular, and they believe the bile to be a solvent of fat by combining with it mechanically. A simple experiment, the correctness of which may be tested by any one, would seem to corroborate the justness of the former view. If a rabbit be killed about an hour after it has been fed, and the contents of the stomach emptied into a piece of muslin, a limpid fluid may be expressed, which, when mixed with bile from the same animal, forms a milky compound which has all the physical characters of chyle. The experiments of Dr. Beaumont also confirm this view. The following, therefore, appear to be the offices of the bile:—1. It is an excretion by which noxious or useless substances are disposed of, viz.:—the colouring matter and resinous portion; 2, by it the chyme is converted into chyle, or, as Prout supposes, albumen is produced from the food; 3, it appears to act the part of a stimulant to the peristaltic motion of the bowels, as obstruction of the gall-ducts is accompanied by constipation, and the sudden removal of the impediment, by diarrhœa. That the bile sometimes finds its way into the stomach, is clearly proved by its being vomited. This fact, taken in conjunction with that above alluded to, regarding the arrest of artificial digestion by the addition of bile, may account for many of the phenomena connected with indigestion, and its attendant symptoms. The flow of the bile and pancreatic secretion is probably occasioned principally by a stimulus propagated from the duodenum along the ducts: indeed, recent investigations seem to render it probable that at least the ductus choledocus possesses a covering of muscular fibres belonging to the unstriped variety.* The contiguity of the duodenum and gall-bladder may likewise aid in the evacuation of the latter, when the former is distended.

In the small intestines, both the chyme and chyle are modified according to the nature of the food: thus, gelatin, when taken, may be detected; so likewise casein, when cheese is eaten, and starch after oats, or cheesey clots after milk; but albumen and casein, especially the former, are most generally and abundantly present. The office of absorbing the chyle, or nutritious portion of the food prepared for circulation, is not confined to the absorbent vessels of the small intestines, though it is principally performed by them: but that the large intestines have a share in this process, is proved by authentic instances of individuals being nourished for a lengthened period exclusively by injections of nutritious matter per anum,—a proceeding successfully resorted to where the powers of life are ebbing, and the stomach is incapable of receiving, digesting, or passing onwards its contents, as in scirrhus of the pylorus, stricture of the œsophagus, &c.

The vessels by which the Chyle is absorbed from the intestine are named *Lacteals*. They take their course between the layers of the mesentery, and terminate in the thoracic duct; passing, in their progress, through the mesenteric glands, where some further modification of their contents, which is not fully understood, takes place. The mode by which the lacteals absorb the chyle is involved in considerable mystery. Dutrochet conceived that in animals as well as plants the process of absorption was due to the law of endosmose. To capillary attraction also the property has been attributed; but be this as it may, it is clear that the lacteals must communicate by open mouths with the surface of the intestine. It has been justly remarked by Müller,† that the intestinal villi cannot under any circumstances be the only organs of absorption, as they do not exist in all animals; but he seems to assign this office to the orifices of Lieberkuehn's follicles. When chyle is obtained from the thoracic duct, it is found to differ from lymph (which is limpid) in presenting a white milky appearance. The microscope demonstrates the existence of globules, about one-half or one-third the size

* See Todd's and Bowman's *Physiology*, p. 162.

† *Physiologie des Menschen*, vol. i., p. 254.

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of blood corpuscles. Like the blood, the chyle coagulates spontaneously, on exposure to the air, in about ten minutes, separating into a solid portion and serum; at least such is the case with that taken from the thoracic duct, though Tiedemann and Gmelin believe that this property is not acquired until after the chyle has passed the mesenteric glands, when it is also observed to assume a red tinge: it would, therefore, seem probable, that in these bodies some elaboration of the fluid takes place by which it becomes more assimilated to the blood. The coagulum of the chyle is, as in the blood, the fibrinous portion mixed with globules; and Müller states that the serum is a solution of albumen mixed likewise with globules, on the surface of which fatty particles collect. The following are the most striking points of difference, noticed by this physiologist, between the chyle and blood:*—1. The globules of the former are insoluble in water, whereas the blood corpuscles are so soluble, even to their nuclei. 2. The absence, in chyle, of the red colouring matter of the blood (not constant). 3. The form and size of the globules differ. 4. The alkaline re-action of the blood is greater. 5. The chyle contains less solid matter than the blood; and the proportion of fibrin is remarkably contrasted in the two, being far more abundant in the blood. 6. The chyle contains fat in a free state, whilst that of the blood exists exclusively in combination with other matters. 7. Both contain iron, which is more easily extracted, by the action of reagents, from the chyle. There are also other points of difference, but of less importance. The experiment of placing a ligature on the thoracic duct generally proves fatal in a period varying from a week to a fortnight, and results apparently from simple inanition. Where death does not ensue, it may be presumed that there are two ducts, or that some other abnormal arrangement exists.

The mucous membrane of the intestines has been described as a secreting surface; and doubtless this secretion is of importance in the process of assimilation. This is probably more especially the case as regards the cœcum, which is particularly large in herbivorous animals, although the peculiar function of this enlarged portion of the alimentary canal is not understood. The mucous fluid in the upper part of the small intestines is usually found to contain some free acid, with albumen, biliary matter, the usual salts of animal fluids, and some other unimportant and accidental substances. These conditions, however, vary in different animals: in the cœcum of herbivora, Schultz found a decidedly acid re-action: but in carnivora, where the cœcum is much less developed, this was usually not the case. Thus, the ingesta, in their progress through the alimentary canal, become separated into the nutritious and excrementitious portions; and as the absorption of the former or more fluid part continues during the onward passage of the mass, the latter gradually assumes a more and more consistent character. The motion of the intestines, by which their contents are carried forward, is vermicular or peristaltic, the course of the undulations or waves being directed towards the anus. This motion may be readily excited in a recently-killed animal by mechanical stimulants, electricity, or even by simple exposure to the air: it would, moreover, appear to be under the control of the sympathetic system of nerves, as complete isolation from cerebro-spinal influence, by removal of the viscera, does not arrest or alter the normal character of the intestinal movement. The Sphincter ani unquestionably possesses a tonic contractile power, to which volition occasionally lends its aid.* The great bulk of the solid portion of the fæces is found to consist of the indigestible and unnutritious parts of the food, and therefore varies according to the nature of the aliment taken, the colour being due to the bile. The following analysis of human fæces is given by Berzelius, in his *Animal Chemistry*, p. 268:—

| | | | |
|---|---|---|---|
| Water | | | 75·3 |
| Soluble in water. | Bile | 0·9 | 5·7 |
| | Albumen | 0·9 | |
| | Peculiar extractive matter | 2·7 | |
| | Salts | 1·2 | |
| Insoluble residue of the food | | | 7·0 |
| Insoluble matters superadded in the intestine—mucus, biliary resin, fat, peculiar animal matter | | | 14·0 |
| | | | 102·0 |

The gas which is found in the alimentary canal seems to be derived from several sources, and varies in character according to its position: it is swallowed with the food; generated by decomposition; and may possibly be secreted. The gases usually met with are, carbonic acid, hydrogen, and nitrogen; and, in addition to these, carburetted and sulphuretted hydrogen in the large intestines.

It has been stated that the nutritious part of the food is conveyed, in the form of chyle, along the lacteals to the *Thoracic duct*, which commences by a distinct dilatation, named *Receptaculum chyli*, the position of which is between the aorta and body of the second lumbar vertebra. From this point the duct ascends into the posterior mediastinum, through the aortic opening in the diaphragm, and between the aorta and vena azygos. About opposite the sixth dorsal vertebra it bends towards the left side, and then ascends behind the arch of the aorta, to occupy the interval between the left subclavian and carotid arteries. Opposite the last cervical vertebra it hooks downwards and inwards behind the left inferior thyroid artery and internal jugular vein, and opens into the posterior part of the left subclavian vein, close to its junction with the jugular, to form the vena innominata. Regurgitation from the vein is prevented by a double valve which guards the aperture. The chyle is thus conveyed to the right side of the heart, whence it passes through the lungs, before it forms a part of the general circulating fluid.†

Before closing the present section, it will be necessary to make a few remarks on *Hunger* and *Thirst*. Many vague and ill-founded theories have been advanced to account for these sensations. One hypothesis gained considerable credit, which attributed hunger to the action of the gastric juice upon the mucous membrane of the empty stomach; but the fact that mental emotions destroy the appetite discountenances this suppo-

* *Op. Cit.*, vol. i., p. 548.

* This subject is further discussed under the head 'Nervous System.'

† For particulars respecting the structure of the Lacteals, see 'Lymphatic System.'

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sition; in addition to which, it is ascertained that the digesting fluid is not generally secreted, except scantily, until it is needed.* It is most probable that hunger is a specific sensation referable to the nerves of the stomach; and experiment would seem to indicate the pneumogastrics as its special seat, for it is said that with their division appetite ceases. Thirst again is referred to the mouth and fauces; and no doubt these parts partake of the susceptibility to a sensation which is in reality common to the whole mucous membrane of the gullet and stomach; but it has been proved experimentally, that moistening the mouth, fauces, and pharynx, without supplying the stomach, are insufficient alone to allay thirst. When food is withheld, a sense of faintness takes the place of hunger. All the functions of the body are performed slowly and imperfectly; the secretions gradually diminish, and at length cease; and every part of the frame which the system can feed upon is taken up by the absorbents. Thus, emaciation goes hand in hand with increasing debility; and the passions are variously affected,—despondency, rage, delirium, alternating. Experiments (even the allusion to which is loathsome) prove that warm-blooded animals are least capable of resisting the effects of want of food. Man usually sinks soon, though there are some remarkable instances in which life has not become extinct for a fortnight or three weeks. The tormenting pangs of hunger soon yield to the intensity of the suffering occasioned by the want of drink, as attested by the painfully interesting accounts we receive from time to time of shipwrecked mariners. Water alone will protract life for a considerable period.

* It is not improbable that the well-authenticated instances which have occurred, of the stomach itself being found partially digested after death, may have lent their countenance to the theory alluded to. But the fact is, that living structures wholly resist the solvent power of the gastric juice, and therefore the stomach cannot have been thus acted on until after death.

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# ANATOMY.

## SECTION VI.

### ORGANS OF CIRCULATION.



The *Thorax*, or *Chest*, occupies an intervening position between the head and neck above and the abdomen below. It contains the organs of respiration and the fountain-head of circulation; and presents several remarkable points of contrast with the containing cavity of the digestive viscera, by which it is better adapted for the fulfilment of its peculiar offices. The properties of resistance, distensibility, and elasticity are here combined, by which protection to the important organs it contains, and a ready performance of their several functions, are admirably provided for. The form of the chest, whilst still clothed with the soft parts, and with the arms attached, conveys to the mind the idea of an inverted cone, which, however, is deceptive; for, when stripped of the above parts, the base of this imperfect cone is seen to be below, and its narrow part, or truncated apex, above. The sternum and costal cartilages form the anterior boundaries of the thoracic cavity; the dorsal division of the vertebral column, and the ribs, as far as their angles, bound it posteriorly; whilst the intervening portion of the ribs (between their angles and cartilages) and the intercostal muscles are its lateral boundaries: below, the diaphragm forms the septum between the chest and belly; and the superior narrow outlet is occupied by the trachea and œsophagus, with muscles, vessels, and nerves. When the skeleton of the chest is viewed in front, its anterior wall is observed to extend obliquely downwards and forwards, and to present a deep notch below, which is bounded laterally by the costal cartilages: the ensiform cartilage projects downwards from the lower extremity of the sternum into the centre of this notch. From this arrangement it results that the vertical diameter of the thorax is greater behind than in front, and that the axes of the outlets do not correspond. The mobility of the walls of the chest is essential to the respiratory acts, and is provided for by the nature of the articulations between the heads and tubercles of the ribs with the vertebræ on the one hand, and on the other by the long elastic cartilages, and their mode of union to the sternum and to one another.*

The Heart is placed in the centre of the chest, between the two lungs,—being attached at its base by the great vessels which carry the blood to and from it to the surrounding parts, whilst its apex is free and points towards the left side. This important viscus is loosely surrounded by a dense fibrous capsule or bag, which is lined by serous membrane: to this attention will be first directed. The *Pericardium*, as this bag is named, is closely adherent to the great vessels at the base of the heart, and also presents a broad, extended, and intimate attachment to the great central tendon of the diaphragm. In consequence of this arrangement, the narrowest or most contracted part of the pericardium corresponds to the base of the heart; and the converse is of course likewise the case. Anteriorly and posteriorly this membrane bounds the corresponding mediastinum; laterally the pleuræ separate it from the lungs; and on the great vessels which it surrounds it is found gradually to lose its fibrous character, becoming continuous with the condensed cellular tissue in the neighbourhood: sometimes a deep layer of the cervical fascia may be traced downwards on the vessels of the neck until it becomes identified with the fibrous pericardium. The serous membrane is to be examined by opening the bag: it is then found to consist of an investing and reflected layer; the former closely surrounding the structure of the heart, and the latter lining the fibrous membrane just described. The points of reflection by which these two layers are rendered continuous are the great vessels proceeding to and from the heart. The serous investment of the aorta is the most extensive; that of the vena cava corresponds to the point of entrance to the vena azygos; and that of the pulmonary artery is limited to the main trunk. Both right and left pulmonary veins are likewise invested by this membrane as they approach the heart; as also the very small portion of the inferior vena cava that is seen within the pericardium. All these vessels are thus surrounded by serous membrane, except at such points as they are in contact with each other. The functions of this important sac are very apparent: for not only does the double serous layer, with its smooth and lubricated surface, permit the free motion of the heart, but the dense fibrous exterior also protects this viscus from external pressure. The pressure here alluded to is that of the distensible viscera on either side of the chest; and the provision to arrest the encroachment of the lungs affords an interesting illustration of the simplicity and perfection of the mechanism, combined with economy of the means. It is during the act of inspiration that the heart's action is most liable to interference from the inflation of the lungs; but this act is effected by the descent of the diaphragm, and with this muscle the broad base of the pericardium is also drawn down; and thus there is even increased space for the play of the unattached portion of the heart, at the same time that the lateral walls of the bag are made tense, and the too close embrace of the lungs is averted.

The *Heart* is a muscular sac, of an irregularly conical form, consisting of right and left divisions, each of which is subdivided into two chambers, severally called auricle and ventricle. The *exterior* of the heart presents for observation its base, which is directed up-

* For further particulars the reader is referred to the 'Bones and Ligaments of the Chest,' in the section 'Osseous System.'



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Anatomy. wards, backwards, and to the right side, and its apex, which points in the opposite direction, corresponding to the fifth intercostal space of the left side. The superior surface is convex, whilst the inferior is flat and triangular in form, and rests opon the diaphragm. The anterior margin is thin, and inclines downwards and to the right side; and the posterior or obtuse margin looks upwards and to the left side, corresponding to a depression in the left lung. Of the two sides of the heart, the right belongs to the pulmonary circulation, whilst the left is the systemic. Further, the auricles are the receptacles, and the ventricles are the propellers, of the blood.

The *interior* of the Heart presents, therefore, four cavities for observation, which communicate directly, or through the medium of vessels, with each other. They will be described in the order in which the blood circulates through them. The *right Auricle* partly rests on the diaphragm, and consists of a posterior dilated portion called the sinus, and an anterior loose portion called the appendix. The interior of this cavity presents the openings of the two venæ cavæ, which are situated at the back part of the sinus, and are separated by a very slight prominence, called the tubercle of Lower. The left wall of the auricle is almost exclusively membranous, and constitutes the septum auricularum: in this is a depression (fossa ovalis) circumscribed by a thick margin (annulus), marking the original communication between the auricles during fœtal life. In the anterior wall is the contracted circular orifice of the appendix: the interior of this division of the auricle presents muscular bands, called musculi pectinati. Anterior to the orifice of the inferior cava the semilunar Eustachian valve is seen: this partly surrounds the above opening, and is likewise connected to the left limbus of the fossa ovalis, which latter is separated by it from the orifice of the coronary vein. The orifice of the last-named vessel is between the Eustachian valve and the ventricle; and it is protected by a crescentic redoplication of the lining membrane, named the smaller Eustachian valve. The openings of other small veins are likewise seen on the interior of this cavity. Lastly, in the anterior and inferior part of the auricle is seen the auriculo-ventricular communication, which is circular, and marked by a well-defined, elevated, and whitish line. The *right Ventricle* is a hollow cone, with its base towards the auricle, and its apex directed towards, though not extending as far as, the apex of the Heart. The two Ventricles are separated by a thick muscular septum, which encroaches upon the right cavity, and evidently belongs to and more especially influences the left Ventricle. Not only is the structure of the ventricular parietes essentially muscular, but their internal surface is rendered irregular by fleshy bands or columns, some of which are attached through their whole extent; others are free in the centre; and a third set, which are the most massive, are connected by broad fleshy attachments towards the apex of the Ventricle, and give off from their extremities small round tendons (chordæ tendineæ) which are inserted into the auriculo-ventricular valves. The base of the Ventricle presents two openings, the auricular and arterial: the former of these is posterior and to the right side of the latter, and is circular when distended, but elliptical when at rest. To the margin of this opening is attached the broad reflection of the lining membrane, which, from its threefold division, is named the tricuspid valve: to each of these folds the tendinous chords above noticed are attached; the left division is the largest, and is interposed between the auricular and arterial openings. The contracted orifice of the *Pulmonary artery* occupies the highest part of the ventricle, and is anterior and to the left side of the auricular opening. This vessel is connected to the heart by means of the external serous and lining membranes, between which the proper arterial coat is disposed in a triple crescentic border, which is attached to the muscular structure of the Ventricle; corresponding to this border the lining membrane is thrown into three folds, which are named the semilunar valves, and present their convex attached margin towards the heart, whilst the floating edge is free and projects into the artery, presenting in the centre of each a little cartilaginous body named corpus sesamoideum. From this origin the pulmonary artery proceeds upwards, backwards, and to the left side, forming a curve, the convexity of which is directed forwards and to the left side: it has of the appendices of the auricles one on either side of it, and is at first anterior to, but subsequently to the left side of, the aorta. After a course of about two inches within the pericardium, it divides just as it leaves this sac into right and left branches, and is connected at the point of bifurcation by a ligamentous chord to the under part of the arch of the aorta: this chord was originally the ductus arteriosus. The right branch of the pulmonary artery is the longer, and takes a transverse direction behind the descending portion of the arch of the aorta and the vena cava superior to the right lung, where it divides into three branches, which ramify in its interior. The left branch of the pulmonary artery ascends between the left bronchus and first division of the aortic arch, and above the left auricle, to the root of the corresponding lung, where it divides into two branches prior to entering its structure. The *Pulmonary Veins* which collect the blood from the lungs are two in number on each side: in the root of the lung they lie anterior and beneath the corresponding artery, and empty themselves into the left auricle of the heart. The *left Auricle* is of a cuboidal form, occupying the posterior and superior part of the heart; its capacity is smaller than that of the right side, but, like the ventricle, its parietes are thicker and more muscular. Above and to the left side is seen the appendix, which is small and irregular in outline: it overlaps the left border of the pulmonary artery. The interior of this cavity presents similar characters to that of the right side, viz., the musculi pectinati of the appendix; the smooth septum, presenting a less defined depression, marking the original existence of the oval foramen: the orifices of the four pulmonary veins are seen in the posterior wall of the cavity, those of the left side not unfrequently terminating by a common opening, and a short distance below that of the appendix. Lastly, the communication with the left ventricle is seen at the anterior and inferior part of the auricle; it is somewhat smaller, but otherwise similar in character to that of the right side. The *left Ventricle* is conical, like the right, its apex extending quite to the apex of the Heart. It presents an arrangement of muscular fibres similar to those of the right ventricle, than which its parietes are thicker, but its capacity is less. The auricular and arterial openings occupy the upper part or base of this cavity: of these the former is posterior and a little to the left side of the

latter, and is guarded by a valve similar to the tricuspid, but divided into only two folds, whence it is named mitral: the anterior of these laminæ is interposed between the arterial and auricular openings. The position of the *Aortic* orifice is at the upper and anterior part of the ventricle, and the attachment of the Aorta to the Heart does not differ from that of the pulmonary artery. Its interior presents the same disposition of the lining membrane, constituting three semilunar valves, opposite to which the artery presents three small dilatations, which are called the lesser Aortic sinuses: the fleshy fibres of the ventricle are strongly inserted around the festooned border of the middle arterial coat; and its attachment is further strengthened by an annular arrangement of tendinous fibres, which are even present in the angular interval between the convex flaps above described. The whole interior of the Heart is lined by a delicate, smooth, transparent membrane, continuous with that which lines the blood-vessels, and partaking more of the character of the serous than any other class of membranes. It is denominated the *Endocardium*, and is more attenuated in the right than in the left cavities: its thickest part on either side is opposite the auriculo-ventricular and arterial openings.

*Structure and Functions of the Heart.*—The arrangement of the muscular fibres of the ventricles is oblique or spiral. Each ventricle has its proper envelope, which is perforated at the base and apex. The fibres common to both ventricles wind spirally around the former, and may be traced into the interior of each cavity at the aperture above alluded to. Both the superficial and deep fibres are connected to the tendinous rings at the base of the ventricles, and are found more or less intermingled at different parts. The spiral direction of the superficial fibres is from the base to the apex of the ventricles, the inclination of the anterior set being from right to left. The principal muscular fibres of the auricles are disposed in transverse or oblique bands in different planes, which connect the auricles together, or are appropriated to each individually; an annular arrangement may also be observed around the auriculo-ventricular openings.

The passage of the blood through the heart is effected by the alternate contraction of the auricles and ventricles. Of these, one auricle and one ventricle are appropriated to the pulmonic circulation, and constitute the right side of the heart: the cavities of the left side belong to the systemic circulation. In tracing the course of the blood, it is found to enter the right auricle by the two venæ cavæ, which collect this fluid from all parts of the system. When distended, this cavity contracts and empties itself into the right ventricle, which in turn expels its contents into the pulmonary artery. So far purple or venous blood is in circulation; but in the lungs, those changes (to be hereafter noticed) by which it becomes decarbonized, take place, and arterial blood is returned by the pulmonary veins to the left auricle. Here the same order of distension and contraction ensues as that which has been described in the right side of the heart—viz., the auricle empties itself into the ventricle, which then propels its contents through the whole system by the large arterial conduit, the aorta. Hence this double circulation has been not inaptly compared in its course to the outline described by the figure 8. It will be evident, from the above description, that the contraction of the auricles must be synchronous with the dilatation of the ventricles, and *vice versâ*. The contraction of the ventricles is called the *systole*, and their dilatation the *diastole* of the heart. The persistence of the heart's contraction is, doubtless, in great measure dependent upon the presence of blood in its cavities, and upon its own especial supply; but the fact that this organ, if removed from the body of a recently killed animal, and placed in warm water, will continue to act rhythmically for a lengthened period when thus isolated, is a proof that these causes alone are insufficient to account for the heart's action. Doubtless, all muscular contraction is associated with nervous influence; and in seeking for that which presides over the heart, anatomy and physiology both indicate the sympathetic as the system to which that influence is due. In this respect, therefore, the fountain-head of the circulation may be placed in the same category with the membranous chylopoietic viscera, which it much resembles in the phenomena above alluded to. In each, analogy will permit the assumption that ganglia (the sources of nervous influence in the sympathetic system) are present in the texture of the organs over which they preside; and are thus capable of exercising a control which, though necessarily limited, is more protracted than that of other nervous centres which do not form an integral part of the muscles they supply. Though it may be difficult to assign the direct cause of the alternate contraction of the auricles and ventricles, it is probably referable to the same law which governs the peristaltic action of the intestines, the wave of which invariably (that is, with rare exceptions, and from the operation of abnormal causes) proceeds in one direction: and it appears not improbable that an inverted action of these cavities, from obstruction or other causes, may account for some instances of sudden death where no important lesion is found.

The muscular strength of the auricles and ventricles, and the relative development of the corresponding cavities on either side of the heart, is proportioned to the amount of exertion required of them. Thus the auricles are little else than passive recipients of the blood, their only active office being to pass that fluid on to the ventricles; and, again, the strength of the left ventricle much exceeds that of the right—an anatomical difference which is readily accounted for by the extent and diffusion of the systemic, as compared with the pulmonic, circulation. The *valves* in and near the heart are the auriculo-ventricular and arterial. As the position and attachment of these have been already described, it only remains to notice the mode in which they perform the office of preventing regurgitation from the ventricles into the auricles, and from the arteries into the ventricles. The position of the tricuspid and mitral valves within the ventricles, and their attachment to the circumference of the aperture between them and the auricles, permit of an uninterrupted progress of the blood from the latter cavities into the former. The fleshy columns, which are attached through the medium of tendinous chords to the free border of the valves, contract coincidentally with the muscular parietes of the ventricle, and thus raise these flaps so as to allow them, during the emptying of this cavity, to be thrown back against the auriculo-ventricular opening; and in this way the natural tendency to a retrograde course of the blood is effectually provided against. The position of the anterior lamina of the mitral





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valve, between the auricular and aortic openings from the ventricle, has led (and probably justly) to the belief that it further operates, during the filling of the last-named cavity, as a valve to prevent the gradual escape of the blood into the aorta: it is questionable whether a similar function can be correctly attributed to the tricuspid. The use of the semilunar valves of the aorta and pulmonary artery is similar, the only difference being that they are unprovided with any muscular apparatus, and are, therefore, forced back against the arterial orifice by the regurgitating tendency which is arrested by them. The corpora sesamoidea in these valves complete the little interval, which would otherwise have been left by the adaptation of three convex outlines.

The *sounds*, which are distinctly audible during the action of a healthy heart, consist of one which is comparatively dull and protracted, and synchronous with the systole of the ventricles; and of a second, which is clearer, and more abrupt, and immediately succeeds the former. A period of repose, equivalent to that occupied by the second sound, then intervenes before the first sound is repeated. Many theories have been broached to account for these phenomena, and each has something plausible to recommend it. The most probable appears to be that which attributes the first sound to the impulse of the blood against the auriculo-ventricular valves; and the second to a similar cause, operating in a like manner upon the semilunar valves. It is difficult to say positively why the apex of the heart is projected forwards at each systole of the ventricles: perhaps it is rather to be attributed to the reflected impulse just spoken of, than to any other cause; though, probably, this explanation is not by itself a satisfactory one.

During uterine life the attachment of the *Fœtus* to the placenta, and the vicarious function of the liver, give rise to remarkable deviations in the course of the circulation, which cease immediately after birth. Two arteries (hypogastric) convey the blood from the fœtus to the placenta, and one large vein (umbilical) returns it in a purified condition to the child: the former vessels are continuous with the internal iliac arteries, and the latter passes to the horizontal fissure of the liver. On arriving at this latter point the stream of the blood is unequally divided, a larger portion first passing through the portal system of the liver, and being thence conveyed to the vena cava ascendens by the hepatic veins, and a smaller stream being transmitted directly by the ductus venosus, and through one of the left hepatic veins, into the vena cava. The re-united streams then proceed to the right auricle of the heart. Here a further diversion of a considerable portion of the blood takes place through the foramen ovale into the left auricle, whence it is conveyed through the left ventricle into the aorta. The peculiar attachment and development of the Eustachian valve, at this period of life, seem to indicate that one of its uses is to direct the stream from the inferior cava to the communication between the auricles. Some portion of the blood, however, takes the same course as in extra-uterine life, and is thus conveyed into the pulmonary artery; but the greater part of this divided stream is diverted in its progress towards the lungs, and conveyed by the ductus arteriosus into the aorta, being thence distributed, in company with the stream which passed directly from the right to the left auricle, throughout the system. Lastly, at the bifurcation of the common iliac arteries the current is once again unequally divided, the larger division passing along the internal iliac and hypogastric arteries, and thus arriving at the placenta. The blood is returned from the lungs, and all parts of the system, in the same way as after birth. Whatever may be the proximate cause of the altered course of the blood immediately after birth, it is clearly associated with the act of respiration: and, therefore, it may be fairly concluded that the enlargement of the thorax, and expansion of the lungs, operate most importantly in diverting the circulating fluid from its accustomed course up to the period of birth; and it may also be presumed that these causes operate both positively and negatively—positively by soliciting the circulation through the lungs, and negatively by withdrawing it from the circuitous course it takes during fœtal life.



Arterial System. (*Das Arteriensystem*, Germ.; *Le Système Artériel*, Fr.)

The *Aorta* is the main systemic arterial trunk. It is attached, as already described, to the base of the left ventricle, from which cavity it conveys the purified scarlet blood over the whole frame. The commencing portion of the aorta is in the form of an *Arch*, which is divided into three segments, named according to their course, and terminating on the left side of the third dorsal vertebra. The first or ascending division of the arch passes upwards, forwards, and to the right side, being, at its highest point, on a level with the cartilage of the second rib: the middle or transverse portion still inclines slightly upwards, at the same time passing backwards and to the left side of the second dorsal vertebra, where the descending division commences, and takes a vertical direction to be continuous with the thoracic aorta. The ascending segment of the arch lies almost entirely within the pericardium, having the vena cava superior to its right side, the main trunk of the pulmonary artery to its left and overlapping it below, and the right branch of that artery behind it: anteriorly it approaches the sternum above. The transverse division of the arch rests upon the trachea a little above its bifurcation, and is crossed by the left pneumogastric nerve, the recurrent branch of which winds to its posterior aspect: the left brachio-cephalic vein crosses its upper border, and the ligamentous remains of the ductus arteriosus are attached to its under part. The descending portion of the aortic arch corresponds to the left side of the bodies of the second and third dorsal vertebræ, being covered by the root of the left lung, and lying between the œsophagus and thoracic duct on the right, and pleura on the left side. Through the remainder of its course, until it reaches the diaphragm, the aorta is called *Thoracic*; and below that point to its bifurcation it receives the name of *Abdominal*. In viewing the artery through the whole course of its descent, it is found to follow the curvatures of the spine, to which it is closely applied, holding nearly a median position as it passes from one cavity to the other, but being quite to the left of middle line, both in the thorax and abdomen. Its relations, whilst superior to the diaphragm, are, anteriorly to the pericardium, root of the left lung and left auricle above, and the œsophagus, lower down: the vein or veins which collect the blood from the left intercostal spaces pass behind it: the reflected pleura covers it on the left; whilst the

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 other contents of the posterior mediastinum, viz., the vena azygos, thoracic duct, and œsophagus lie on its right. In passing into the abdomen, the aorta pierces the crura, so as to be invested by them for a considerable distance. As it descends, it inclines to the left side, and bifurcates usually on the fourth lumbar vertebra. In this course, the right crus of the diaphragm, receptaculum chyli, sympathetic nerves, and left lumbar veins separate it from the spine: the pancreas, arch of the colon, stomach, and small intestines, with the omentum and mesentery lie anterior to it, and the left renal vein crosses it: the left crus of the diaphragm lies to its left side, and the vena cava ascends on its right, but is separated from it above by the right crus of the diaphragm, lobulus spigelii of the liver, commencement of the vena azygos, and thoracic duct. The branches of the Aorta are derived severally from its arch, from its thoracic and from its abdominal divisions. Those of the arch are five in number, viz., two coronary, right brachio-cephalic or innominata; left carotid, and left subclavian.

*Arteria Coronaria dextra vel posterior* arises from the commencing portion of the aortic arch, immediately external to one of the semilunar valves, and to the right of the pulmonary artery. It takes a tortuous course along the groove which separates the right auricle and ventricle to the posterior aspect of the heart, where it divides into two branches: the smaller of these continues in the same groove, whilst the larger descends posteriorly on the septum of the ventricles to the apex of the heart. Each of these branches ultimately anastomoses with corresponding branches from the left coronary artery; and in their course the following parts are supplied: the commencement of the great vessels; the right auricle and auricular septum; both ventricles (especially the right), and their septum. Some of these twigs are separated before the bifurcation of the trunk: the two branches further communicate with each other.

*Arteria Coronaria sinistra vel anterior* is smaller than the right, and has a similar origin, but the pulmonary artery intervenes between them. It takes its course downwards, forwards, and to the left, under cover of the left auricular appendage, and likewise divides into two branches; one of which, as in the former case, is lodged in the corresponding (left) auriculo-ventricular groove, and terminates by anastomosing with the superior branch of the right artery. The inferior and larger branch descends on the ventricular septum anteriorly, and inosculates with the inferior division of the right artery. By this artery the left side of the heart is supplied: twigs are also given to the commencement of the great vessels, and to the right ventricle; but the left ventricle receives the largest supply.

*Arteria Brachio-cephalica vel Innominata* is a large trunk, which, after a short course, divides into right carotid and subclavian arteries. It is the first branch arising from the transverse division of the aortic arch. Its course is upwards, with an inclination backwards and to the right side; and it bifurcates opposite the right sterno-clavicular articulation, the average length of the trunk in the adult very little exceeding an inch. This artery lies behind the sternum, and is first related to the trachea, in front of which it arises: at its bifurcation it is on the right side of the air-tube. Its origin is overlapped by the left brachio-cephalic vein; the middle thyroid veins lie on its left side; and the pneumogastric nerve is on its right, closely approaching it above at its termination, but separated below. 

*Arteria Carotis sinistra* arises from the transverse portion of the arch of the aorta, close to the arteria innominata, where it is covered by the sternum and sterno-hyoid and thyroid muscles. Its direction is upwards, and it inclines at the same time to the left side, so as to leave the trachea on its right. Its origin is crossed by the left brachio-cephalic vein, and its outer border overlapped by the left jugular vein. Its course for some distance is nearly parallel to the left subclavian artery; and the thoracic duct lies imbedded between these vessels.

*Arteria Subclavia sinistra* arises on the left side of the corresponding carotid, from the third division of the arch of the aorta opposite the second dorsal vertebra; and ascends nearly vertically, with a slight inclination towards the left side, to the inner border of the anterior scalenus muscle. In this course it is nearly parallel to the left carotid, which, with the œsophagus, is internal to it: externally and in front it is in contact with the bag of the left pleura, which separates it from the lung: it is crossed superficially near its origin by the left pneumogastric nerve; and the left brachio-cephalic vein overlaps it above: the sternum and sternal muscles also cover it. Lastly, it lies upon the vertebræ, longus colli muscle, and inferior cervical ganglion of the sympathetic.*

*Arteriæ Carotides communes.*—The carotid artery of the right side arises opposite the sterno-clavicular articulation from the innominata: that of the left side, gains a corresponding position by taking the course already described. The two vessels diverge as they ascend, and usually bifurcate opposite the upper border of the Thyroid cartilage. Each vessel is deeply placed in the lower part of the neck, but comparatively superficial above: in the former position it lies beneath the platysma-myoides, sterno-mastoid, hyoid and thyroid, and omo-hyoid muscles; whilst in the latter, *i. e.* opposite the cricoid cartilage, and above the point of separation of these muscles, it is covered by the platysma and fascia alone. The crossing of the omo-hyoid muscles further divides the course of the common carotid artery into inferior and superior portions. Below, the two arteries are near to each other, but above they are separated by the œsophagus and trachea, and higher up by the larynx and pharynx: the thyroid body is also interposed between them, and its lobes (especially if large) more or less overlap them. Posteriorly each vessel is related to the inferior thyroid artery, the sympathetic and recurrent laryngeal nerves, which separate it from the spine and longus colli muscle: the vertebral artery is also behind it, but soon enters the foramina in the cervical transverse processes. The external relations of the common carotid are the internal jugular vein and pneumogastric nerve, which lie in the same sheath with it, the nerve being between the vessels. The descendens lingualis nerve, and some irregular thyroid veins, lie superficial to the carotid sheath; some lymphatic glands are also found closely connected to it, lying principally to the outer side.

* As the preceding descriptions embrace the principal peculiarities of the left carotid and subclavian arteries, and as the vessels of either side agree in the rest of their course, one description will suffice for both.

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*Arteria Carotis Externa, and its Branches.*—This vessel separates from the internal artery of the same name opposite the upper border of the thyroid cartilage: sometimes the bifurcation of the common carotid is as high as the os hyoides, but rarely lower than the point above indicated. The destination of the External Carotid is to supply the neck, face, and exterior of the head. It first ascends with an inclination inwards towards the submaxillary gland, but soon turns backwards to enter the substance of the parotid, in which it divides into its ultimate branches. In this course it runs parallel to the Vertical ramus of the lower jaw, between it and the external auditory opening; and presents a curvature below, the convexity of which looks upwards and inwards towards the tonsil. It is covered superficially by the platysma and fascia, and is crossed by the digastric and stylo-hyoid muscles, and by the lingual motor nerve: in the substance of the parotid, and near to its termination, it is further crossed by the facial nerve. The stylo-glossus and stylo-pharyngeus muscles, and the glosso-pharyngeal nerve, with the stylo-hyoid ligament separate it from the internal carotid: and the point of bifurcation into its terminating branches is opposite the neck of the lower jaw. Several branches of the sympathetic nerve surround the External Carotid and its divisions. *Arteria Thyroidea superior* is the first branch of the external carotid, and arises usually opposite the cornu of the os hyoides. In its course to the thyroid body it forms an arch, the convexity of which looks upwards, and it is covered by the platysma and fascia, and the omo-hyoid and sterno-thyroid muscles. Its branches are,—1. Hyoidean, which is small, and passes inwards between the os hyoides and thyroid cartilage, and beneath the thyro-hyoid muscle: it communicates with its fellow. 2. Laryngeal branch, more considerable in size, accompanies the superior laryngeal nerve beneath the thyro-hyoid muscle, to the thyro-hyoid membrane, which it penetrates: it divides into branches, which supply the small muscles of the larynx, the epiglottis, and neighbouring mucous membrane. 3. Posterior branch, which crosses the carotid sheath to be distributed to the lymphatic glands and sterno-mastoid muscle. 4. Thyroid branch, which is the continuation of the trunk, takes a tortuous course along the border of the thyroid gland, and divides into branches which enter its substance and ramify on it superficially: they anastomose with the inferior thyroid of the Subclavian, and with corresponding branches from the opposite side. *Arteria Lingualis*, is usually the second branch of the external carotid: it first passes inwards towards the os hyoides, and then ascends to the under part of the base of the tongue: its third division comprises its course along this organ to its tip. In the first division of its course the cornu of the os hyoides separates the lingual from the thyroid artery, where they are covered only by the platysma and fascia. The former then passes more deeply beneath the hyo-glossus muscle, having also the mylo-hyoideus superficial, and the middle constrictor of the pharynx internal to it. Further on it is placed between the hyo-glossus and genio-hyo-glossus muscles; and, after leaving the former, it continues its course between the latter and the lingualis to its termination. The lingual motor nerve at first lies superficial to and above the artery: the hyo-glossus then separates them, the nerve being still superficial; but from the anterior margin of that muscle they run together to their termination. The lingual artery gives off the following branches:—1. Hyoidean, which is distributed to the muscles attached to the hyoid bone, and to the epiglottis: it anastomoses with its fellow and branches of the thyroid. 2. Dorsal branch of the tongue, arises in the second stage of the artery, and is very frequently substituted by several small twigs: it supplies the tonsil, palate, base of the tongue, and neighbouring mucous membrane. 3. Sublingual, supplies the gland of that name, and the neighbouring mucous membrane of the mouth. 4. Ranine, which is the continuation of the trunk, supplies the structure of the tongue, and its muscles near their insertion; also the mucous membrane of this organ, at the tip of which it anastomoses with its fellow. *Arteria Facialis*, called also labial and external maxillary, arises from the external carotid next to the lingual. The course of this branch is very tortuous from its commencement almost to its termination. It first passes upwards and inwards so as to approach the tonsil, and is covered by the digastric and stylo-hyoid muscles: it next penetrates the substance of the sub-maxillary gland; and, on emerging from it, winds over the horizontal ramus of the lower jaw in front of the masseter muscle. In its subsequent course it lies imbedded in the fat of the cheek, and is crossed successively by the depressor anguli oris, zygomaticus, and part of the levator labii superioris. Its branches are:—1. Inferior palatine, which ascends inwards between the stylo-glossus and stylo-pharyngeus muscles to the palate, which, together with the pharynx, tonsils, and above-named muscles, it supplies; and anastomoses with the palatine branch of the internal maxillary. A distinct branch is frequently separated to the tonsil. 2. Glandular branches supply the submaxillary gland. 3. Submental, a considerable branch, runs parallel to and beneath the horizontal ramus of the lower jaw, under cover of the platysma: it supplies the muscles and glands in this region, and ultimately divides into two branches; one of which gains the median line, where it anastomoses with its fellow, whilst the other is distributed to the skin and muscles of the chin, communicating with twigs from the inferior labial and dental arteries. 4. Inferior labial, supplies the muscles and skin of the under lip, and communicates with those just named. 5. Inferior coronary, runs inwards beneath the depressor of the lower lip and orbicular muscle, and close to the mucous membrane, to supply these parts and join the corresponding branch from the opposite side. 6. Superior coronary, arises near the labial commissure, and has a similar distribution and termination in the upper lip, as the last described has in the lower. 7. Lateral nasal, is distributed to the side of the nose, and anastomoses on the back of that organ with its fellow. 8. The angular artery is the terminating branch of the facial: it ascends between the origins of the levator labii superioris alæque nasi to the inner canthus of the eye, where it is distributed to the neighbouring lachrymal apparatus, and inosculates with branches of the ophthalmic artery. 9. Muscular branches are distributed, in the course of the facial artery, to the masseter, buccinator, and other facial muscles. *Arteria Sterno-mastoidea*, usually comes directly from the external carotid artery, and passing backwards to the sterno-mastoid, supplies it and the deeper muscles. *Arteria Occipitalis* arises from the external carotid usually opposite to the lingual artery. Its course is first upwards and backwards,

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parallel to the posterior belly of the digastric, which covers it, and by which it is directed to the mastoid process of the temporal bone: from the groove on the inside of this process it passes backwards on the occipital bone, and subsequently ascends on the back of the head to divide into its terminating branches. In the early part of its course this artery lies beneath the sterno-mastoid muscle and fascia of the neck, and the lingual motor nerve crosses it in its arched progress to the tongue. It then lies between the mastoid process and transverse process of the atlas, which position it gains by crossing the internal jugular vein and pneumogastric nerve. Lastly, on the occiput before it becomes subcutaneous, it is covered by the splenius capitis muscle, having the trapezius, trachelo-mastoid, and complexus also superficial to it. 1. The Occipital artery gives off several muscular branches to supply the muscles with which it is related: some of these are superficial and anastomose with the superficial cervical, and others are deeply seated and communicate with the deep cervical artery, both branches of the subclavian. 2. It gives off a meningeal branch, which enters the posterior lacerated foramen; and sometimes another which penetrates the mastoid foramen. 3. The terminating branches are tortuous, and correspond to the occipito-parietal suture: they are distributed to the skin and muscles of the scalp, being accompanied by the posterior branch of the first cervical nerve, and anastomosing with the opposite, and with the temporal and posterior aural arteries. *Arteria posterior auris* is small, and when regular, arises a little above the last, after the carotid has entered the parotid gland: sometimes it comes off in common with the occipital. Its course is upwards and backwards between the ear and mastoid process, where it divides. 1. Before bifurcating, this artery gives branches to the muscles and parotid gland. 2. The stylo-mastoid branch is supplied by it, and enters the Fallopian aqueduct by the stylo-mastoid hole: it is distributed to the labyrinth, and anastomoses with other branches supplying the internal ear. 3. Of its terminating branches, one is distributed to the concha, and the other to the mastoid region of the skull. *Arteria Pharyngea ascendens*, even smaller than the last, is usually the earliest branch of the external carotid. It takes a deep course close to the spinal column and pharynx, being crossed by the stylo-pharyngeus muscle, and having the superior cervical ganglion external to it: it lies upon the rectus capitis anticus major muscle. 1. The principal branches of this artery are distributed to the pharyngeal muscles; and many of them supply the Eustachian tube, velum, palate, and tonsil. 2. The great nerves in this region receive branches. 3. Some are distributed to the anterior deep muscles of the neck. 4. The terminating branches are the meningeal, which enter the skull by its posterior and anterior lacerated foramina, and by the anterior condyloid hole: of these the first is the most considerable and constant. *Arteria Transversalis faciei*, arises in the substance of the parotid gland, either from the external carotid itself immediately prior to its ultimate bifurcation, or from the temporal close to its origin. It emerges from the parotid gland and takes a transverse course across the masseter muscle, in company with Steno's duct, above which it lies, and from which it is separated by a large branch of the portio-dura nerve. The branches of this artery are distributed to the parotid gland, and to the masseter and other muscles of the face. They anastomose with branches of the facial artery. *Arteria Temporalis*, is the superficial of the two branches which result from the bifurcation of the external carotid artery: it is somewhat smaller than the deep branch. Its course is vertical; and after emerging from the parotid gland it ascends behind the base of the Zygoma to the temporal region, where it divides into anterior and posterior branches. In this course it is crossed by the anterior auris muscle, and covered by fascia, which accompanies it from the parotid gland: branches of the facial nerve also twine around it. The branches of this artery are distributed, 1. to the anterior part of the auricle and capsule of the lower jaw; 2. a deep temporal branch, which is distributed to the muscle of that name after penetrating the temporal aponeurosis; 3. the anterior terminating branch passes forwards and is distributed to the skin and muscles of the forehead, anastomosing with the supra-orbitar and frontal arteries, and with its fellow; 4. the posterior terminating branch arches backwards, having a similar distribution, and communicating with the occipital and posterior aural arteries. *Arteria Maxillaris interna* leaves the temporal to pass inwards beneath the neck of the lower jaw, where it is covered by the internal lateral ligament of the temporo-maxillary articulation. The subsequent course of this artery is very tortuous: it first curves inwards to the interval between the pterygoid muscles above and below, and the buccinator and insertion of the temporal internally and externally; it then crosses between the external pterygoid and temporal muscle; and lastly penetrates the former to enter the pterygo-maxillary fossa. In this course the artery is nearly related to the divisions of the inferior maxillary nerve, usually separating the dental from the lingual branch. The following are the branches given off by this complex and tortuous artery. 1. Middle Meningeal is the first and generally the largest offset from the Internal Maxillary artery. It arises whilst that trunk is on the side of the neck of the jaw, and arrives at the base of the skull by passing behind to the external pterygoid muscle, and between the tensor palati and internal lateral ligament of the temporo-maxillary articulation. It then enters the cranium by the spinous foramen of the sphenoid bone, and ascending on the temporal and parietal bones between the dura mater and skull, it ultimately divides, and its ramifications extend in an arborescent form over the vault of the cranium. Before this artery enters the skull it gives off twigs to the surrounding soft parts, and the Eustachian tube. Within the skull it sends small branches into the orbit through its lacerated foramen, and one to the ear through the hiatus Fallopii. The trunk and branches of this artery groove the bone almost to their termination, and supply the inner table of the skull and diploe with blood. 2. Inferior Dental artery arises near to the last, and passes between the vertical ramus of the lower jaw and internal lateral ligament to enter the dental canal, which it traverses, in company with the nerve of the same name, as far as the first molar tooth: it here divides into two branches, one of which is a continuation of the trunk within the canal, and destined to supply the canine and incisor teeth; whilst the other escapes by the mental foramen, and divides into a lash of branches distributed to the skin and muscles of the lower lip and chin, and communicating with branches of the facial. Before entering

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Anatomy. the dental canal, this artery supplies the pterygoid and mylo-hyoid muscles; and in the canal each molar tooth receives a branch before its division. 3. The muscular branches of the internal maxillary artery are pterygoid to the two muscles of that name; temporal (usually two), which supply the temporal muscle, and communicate with branches from the superficial temporal; masseteric and buccal, which are distributed to these muscles and the surrounding soft parts. 4. The superior dental branch winds tortuously round the tuberosity of the upper jaw, and sending some twigs in for the supply of the antrum, its remaining branches penetrate the alveoli, and are distributed to the molar teeth. 5. The infra-orbitar branch leaves the spheno-maxillary fossa to enter the infra-orbitar canal, which it traverses in company with and beneath the nerve of the same name, and appears on the cheek between the levator labii superioris and levator anguli oris: in this course it gives off twigs to the antrum, canine, and incisor teeth; and on the face is distributed to the skin and muscles, and communicates with the other arteries in the neighbourhood. 6. The descending palatine branch descends through the posterior palatine canal to the palate, having previously given off the vidian twig: its ultimate distribution is to the velum and palate. 7. The lateral nasal enters the superior chamber of the nose by the spheno-palatine foramen, and is distributed to the upper part of the pharynx and mucous membrane of the nasal fossæ.

*Arteria Carotis Interna, and its Branches.*—The size of this artery is much the same as that of the external carotid in the adult, but considerably exceeds it in the child, at which period the brain is disproportionately developed. Its course is generally divided into three stages, the first of which includes the course of the artery before it arrives at the base of the skull; the second its course through the carotid canal, and the third, its progress through the cavernous sinus before its ultimate division. In its directions and relations, this artery appears as the continuation of the common carotid; for its course is vertical though flexuous: it has the internal jugular vein on its outer side, and par vagum on its inner, and it rests on the rectus capitis anticus muscle and sympathetic nerve. The Internal Carotid lies on a plane external and posterior to the external carotid, and the two vessels are separated, as already stated, by two of the styloid muscles, the stylo-hyoid ligament and glosso-pharyngeal nerve: a portion of the parotid gland is also interposed. When close to the base of the skull, the former vessel is immediately behind the Eustachian tube, and internal to the styloid process; whilst it lies close to the pharynx, and has the tonsil anterior and internal to it. In the carotid canal and sinus the artery is very tortuous, making abrupt turns to accommodate itself to the direction it is required to take; in the latter position its curves resemble the Roman letter S. Its ultimate direction is backwards and inwards, when it terminates on the side of the olivary process of the sphenoid bone, by division into the cerebral arteries. In this course the artery is accompanied by filaments of the sympathetic nerve, and is surrounded by an investment of the lining venous membrane in the cavernous sinus. The relation of the orbitar nerves and artery has been already described.* Whilst situated close to the tympanum, anterior and internal to which it lies, this artery gives off a small tympanitic branch: and just before its ultimate division the ophthalmic artery is separated.* The terminating or cerebral branches of the internal carotid are the following:—1. Choroid branch takes a direction backwards, and enters the inferior cornu of the lateral ventricle, to be lost in the choroid plexus. 2. Lateral communicating branch proceeds backwards and inwards to communicate with the posterior artery of the cerebrum, a branch of the basilar. 3. Anterior artery of the cerebrum passes forwards and inwards above the optic nerve, to the great longitudinal fissure of the brain, and when near the corresponding artery of the opposite side, the two vessels communicate by a large intermediate branch, called the anterior communicating artery. The main vessel then passes backwards in company with its fellow along the corpus callosum, distributing its branches, in its progress, to this commissure, and to either hemisphere of the cerebrum. 4. Middle cerebral artery, considerably larger than the latter, takes its course outwards and backwards to the fissure of Sylvius, and is distributed to both anterior and middle lobes of the cerebrum, but especially the latter. Anatomy.

*Arteriæ Subclaviæ*, of equal size with the carotids, are two in number, their destination being to supply the upper extremities. The origin and early course of each has been already described. The scalenus muscle crosses each subclavian artery in its progress, and has given rise to an arbitrary, though useful, division of the vessel into three parts; the first comprises that portion of the artery which is internal to the muscle, the second that which is behind it, and the third includes the remaining portion of the vessel until it assumes the title of axillary. By referring to the preceding description of the branches as they arise from the arch of the Aorta, it will be perceived that the extent of the right subclavian artery behind the scalenus muscle is comparatively short. Whilst covered by this muscle, the corresponding vein is separated by it from the artery, the former lying on a plane anterior and a little inferior to the former, and more closely connected to the clavicle: the phrenic nerve lies on the anterior scalenus, and is therefore also anterior to the artery, but behind the vein; the brachial nerves are superior and posterior to both vessels. Further, the artery is related posteriorly to the posterior scalenus muscle and summit of the pleura. From the outer border of the scalenus anticus muscle to the lower margin of the first rib, the Subclavian artery lies behind the clavicle and subclavius muscle, in the posterior inferior triangle of the neck. Here the vein is in contact with the artery, but still anterior and inferior to it; and the brachial plexus is more closely applied upon it, so as in part to lie behind it: the supra-scapular artery is parallel and anterior to the Subclavian; whilst the posterior scapular artery and omo-hyoid muscle are above it. Lastly, in this, its third division, each Subclavian artery rests on a portion of the posterior (or middle) scalenus muscle, and grooved upper border of the first rib. The *branches* of the Subclavian artery are subject to considerable variety in their origin, but usually regular in their destination: the ordinary number is five. The *Vertebral* is the largest, and generally the first branch given off from the trunk, whilst internal to the Scalenus

* See 'Organs of Senses,' p. 435.

* This has been already described with the 'Organ of Sight,' p. 435.

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muscle. It ascends, inclining at the same time a little outwards, to arrive at the root of the transverse process of the sixth cervical vertebra, the foramen in which it enters: in this course it lies on the longus colli muscle. In its subsequent course the Vertebral artery passes in succession through the holes in the cervical transverse processes until it reaches the atlas, where its first curve outwards is formed for it to gain the foramen in the transverse process of that vertebra: its second curve is nearly horizontal, the artery inclining backwards to pass behind the articulation of the atlas and occiput, and lying in a deep groove in the former: lastly, it is directed forwards and upwards through the foramen magnum of the occipital bone; and the two arteries converging as they lie on the antero-lateral aspect of the medulla oblongata, ultimately unite to form a single trunk, the Basilar, opposite the junction of the spinal cord and meso-cephalon. Before this junction is effected the following branches are given off from either vertebral artery; 1. small twigs to the spinal nerves: 2. Posterior spinal artery inclines to the back part of the cord, and descends even to the lumbar region, supplying in its progress the cord itself and its investments, and anastomosing with other twigs which enter the vertebral foramina: 3. the Anterior spinal artery, generally arising higher than the last, soon joins its fellow to form a single trunk, which descends tortuously along the anterior part of the cord, even to the cauda equina, in which it ultimately terminates: it gives off supplying and inosculating branches similar to the preceding: 4. the inferior cerebellar artery sometimes comes from the Vertebral, at others from the Basilar; it takes a flexuous course between the branches of the eighth pair of nerves, and is ultimately distributed to the back and lower part of the cerebellum: 5. as the Basilar artery crosses the pons it gives twigs to it: 6. on its anterior and superior extremity the superior cerebellar artery is detached; it winds round the crus cerebri to the upper part of the cerebellum, where it divides into its ultimate branches: 7. the Basilar artery lastly bifurcates immediately after the origin of the last branches, and the resulting pair of vessels is the posterior cerebral: these likewise wind round the crus cerebri, and above the tentorium to the under surface of the posterior lobe of the cerebrum, where they are distributed: in their progress they receive the lateral communicating arteries from the carotids, by which the circle of Willis is completed.* The *internal Mammary* artery arises from the Subclavian opposite the vertebral, and therefore also internal to the Scalenus muscle. Its course is nearly vertical through the chest, and closely applied to its anterior parietes. At first this artery inclines a little forwards and inwards, and is crossed by the phrenic nerve, which subsequently lies to its inner side. In its progress downwards it is interposed, first between the parietal pleura and costal cartilages, and afterwards it insinuates itself beneath the triangularis sterni muscle, its distance from the sternum being less than an inch. The mammary artery gives off from its inner border branches to the muscles and glands in the anterior mediastinum: 2. the comes nervi phrenici, which is ultimately lost in the diaphragm: 3. anterior intercostal and perforating branches, which supply these muscles and the mamma, and anastomose with the proper intercostal and thoracic arteries. Of the two terminating branches the external runs near the margin of the diaphragm, which and the neighbouring intercostal muscles it supplies; whilst the internal or proper abdominal branch descends upon the peritoneum, distributing twigs to the abdominal muscles, and inosculating freely with the terminating branches of the epigastric, lumbar, and circumflexa ilii arteries. The *Thyroid axis* arises from the Subclavian internal to the Scalenus muscle, and nearly opposite the mammary: it is a very short trunk, which inclines upwards and soon divides into four branches. 1. Inferior thyroid is the largest branch: it takes a flexuous course upwards and inwards behind the carotid sheath and sympathetic nerve, and lies upon the longus colli muscle. After supplying twigs to the œsophagus and trachea it terminates in the thyroid body, where it anastomoses with the superior thyroid and its fellow. The left thyroid artery has the thoracic duct also anterior to it. 2. The ascending Cervical branch comes from the last described, or directly from the axis: its course is upwards on the anterior scalenus muscle, parallel and internal to the phrenic nerve; and it is distributed to the deep muscles of the neck, sending branches in through the vertebral foramina, and communicating with the occipital. 3. The Supra-scapular branch (or transversalis humeri) takes a horizontal course to the notch in the upper border of the scapula, crossing anterior to the scaleni muscles and the phrenic and brachial nerves, and lying behind the clavicle, and close to the subclavius muscle: the artery enters the supra-spinous fossa, by crossing above the ligament of the notch; and, after supplying the muscle of this region, proceeds onwards beneath the spine of the scapula to the infra-spinous trench, where it terminates by distribution to the infra-spinatus and teres minor muscles, and by inosculation with the other two scapular arteries. 4. The Posterior Scapular (or transversalis colli) artery takes a parallel and similar course to the last, but superior to it, to arrive at the superior internal angle of the scapular: this branch gives off inconsiderable twigs to the muscles; and the superficial cervical artery, which ascends beneath the trapezius muscle, to which and the neighbouring muscles and glands it is distributed, anastomosing with branches of the occipital. At the superior angle of the scapula the levator anguli scapulæ covers the posterior scapular artery, and receives a branch from it, which also supplies the supra-spinatus muscle; another branch passes outwards beneath the scapula to be distributed to the subscapularis and great serratus; whilst the continued trunk descends along the base of the scapula under cover of the rhomboid muscles, to which and others in the neighbourhood it is distributed, ultimately anastomosing with the subscapular artery. The remaining two branches of the Subclavian artery come off in its middle stage, and not infrequently arise in common. The *Superior Intercostal* artery descends in front of the neck of the first two ribs, sending off a branch which is distributed to the first intercostal space; and then in like manner supplying the second, and communicating with the first intercostal branch of the Aorta. The first thoracic ganglion is external to this artery. The *Deep Cervical* branch takes its course backwards between the transverse processes of the last two cervical vertebræ, and through the brachial plexus of nerves: it then ascends in the interval between the

* See 'Internal Carotid,' p. 468.



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transverse and spinous processes of the vertebræ, and is distributed to the muscles of this region, communicating with the deep descending branches of the occipital artery.

*Arteria Axillaris*, or continuation of the subclavian through the axilla, commences opposite the lower border of the first rib, and extends to the lower margin of the teres major and latissimus dorsi muscles, where the brachial begins. In this course it is crossed by the pectoralis minor muscle, which thus divides it into three stages. Above this muscle the artery lies under cover of the great pectoral, and upon the first intercostal and second digitation of the great serratus muscle; the costo-coracoid ligament also lies in front of it; whilst behind the small pectoral muscle, the brachial nerves begin to surround the artery. Still lower the artery is more closely approximated to the Shoulder-joint, from which it is only separated by the insertion of the subscapular muscle: and lastly, it lies upon the conjoined tendons above mentioned, being still under cover, of the pectoralis major.* The accompanying vein is superficial to the artery throughout its course, but lies also to its inner side above. The following are the *branches* of the Axillary artery: 1. *Acromial thoracic* arises opposite the upper border of the small pectoral muscle, and in the interval between the deltoid and great pectoral: after a short course it divides at once into several branches, of which the majority are lost in the surrounding muscles; one large branch passes outwards beneath the deltoid, which muscle and the shoulder-joint it supplies; and a long descending branch accompanies the cephalic vein, and is distributed to the deltoid and great pectoral muscles. 2. *Superior thoracic*, not infrequently a branch of the last, descends between the pectoral muscles to which and to the mamma it is distributed, anastomosing with the perforating branches of the intercostal and mammary arteries already described. 3. *Alar thoracic*, usually two or three small branches which arise lower down, and are distributed to the parietes and glands of the axilla. 4. *Long thoracic* arises below the lesser pectoral muscle, and descends parallel to its inferior border upon the serratus magnus: to these muscles and the great pectoral and subscapularis it distributes branches, and anastomoses with the perforating branches noticed above. 5. The *Subscapular* is the largest branch of the Axillary artery; it arises opposite the lower border of the subscapular muscle, and descends for a short distance along the corresponding border of the scapula: opposite the inner margin of the long head of the triceps it divides into an anterior branch, which is the smaller, but continues in the same direction as the trunk to the inferior angle of the scapula; and a posterior branch which winds round the external or inferior costa of this bone, leaving the axilla by the opening which has for its boundaries the triceps, teres major, and subscapular muscles; the destination of the former of these branches is to the adjoining muscles of the scapula and chest, whilst the latter is chiefly distributed to the deltoid, infra-spinatus and teres minor: a free anastomosis is established between this artery and the other branches from the subclavian, on the dorsum and inferior angle of the Scapula. 6. The *posterior circumflex* artery arises near the last, and almost immediately leaves the axilla between the humerus and long head of the triceps, accompanied by the circumflex nerve: it winds round the neck of this bone under cover of the deltoid, in which and on the shoulder it is expended, communicating with the next and the superior profunda of the brachial. 7. *Anterior Circumflex*, much smaller than the last-described, is irregular in its origin; its course is forwards and outwards close to the neck of the humerus; and after supplying the neighbouring muscles and synovial membrane of the shoulder-joint, it terminates by anastomosing with the posterior circumflex.

*Arteria Brachialis* extends from the teres major tendon to the point of bifurcation of the main trunk at the elbow-joint. In this course it is superficially placed, being only covered by the fascia, which holds the surrounding muscles together, so as to afford a further protection to the artery. It first rests on the triceps, then on the insertion of the coraco-brachialis, and lastly on the brachialis anticus muscles. In the upper third of its course the artery lies between the coraco-brachialis and triceps, and in the two lower thirds between the latter and biceps muscle: the semilunar fascia of the biceps covers it inferiorly. The Brachial artery is accompanied by a vein on either side. The position of the brachial nerves varies in relation to the artery according to its position: the inner cutaneous nerve is superficial, but parallel to it. the median crosses from its outer to its ulnar side; the radial lies behind it above. Just prior to its bifurcation (which takes place nearly opposite the coronoid process of the ulna), the Brachial artery lies between the biceps tendon and median nerve; and, still resting upon the brachialis anticus muscle, it dips in between the supinator longus and pronator teres muscles to gain the deep position in which it terminates. The *branches* of the Brachial artery are; 1. *Muscular*, which are irregular in number, size, and origin, and are distributed to the neighbouring muscles: 2. *Superior Profunda*, which arises soon after the artery becomes Brachial, and accompanies the radial nerve in a spiral direction beneath the triceps, and around the humerus to its outer aspect, where it divides into two branches; one of these descends in the triceps, to which and the elbow-joint it is distributed: the anterior branch continues to accompany the nerve, and is found lodged with it in the interval between the supinator longus and brachialis anticus muscles, where it terminates by anastomosing with the anterior recurrent branch of the radial. 3. The *inferior Profunda* arises opposite the insertion of the coraco-brachialis muscle, and descends in company with the ulnar nerve to the interval between the inner condyle of the humerus and olecranon of the ulna, where the nerve lies superficially: in this course it pierces the intermuscular septum, and lies on the inner head of the triceps, supplying this muscle and the biceps, and inosculating with the posterior ulnar recurrent artery. 4. The *Anastomotic* branch arises below the last, and takes an inward direction to pierce the intermuscular septum above the inner condyle, after which it terminates by anastomosis with the last and the posterior ulnar recurrent; but prior to this it supplies some muscular twigs, and communicates with the inferior profunda and anterior ulnar recurrent. 5. The *Nutritious* branch to the humerus is detached from the trunk about the middle of the arm: it pierces the coraco-brachialis to enter the foramen in the bone,

* For particulars respecting the relation of the nerves to the artery, see 'Nervous System—Brachial plexus,' p. 444.

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which is directed upwards, and terminates by being distributed to its cancellated interior.

*Arteria Radialis*, though smaller than the ulnar, appears in direction to be the continuation of the brachial. Its position is comparatively superficial, being covered by the fascia, and imbedded between the muscles of the fore arm. In its course to the wrist the radial artery first lies on the tendon of the biceps, and then in succession on the supinator brevis, tendon of the pronator teres, radial origin of the flexor sublimis, flexor pollicis, pronator quadratus, and lastly on the base of the radius: the opposed margins of the supinator longus and pronator teres conceal it above; and in the lower two-thirds of its course it lies between the former muscle and the flexor carpi radialis, being partly overlapped by them above, but left exposed between their tendons below. At the wrist-joint the Radial artery winds on the outer side of the carpus to gain a position between the metacarpal bones of the thumb and index finger; and in this course it lies upon the external lateral ligament of the joint, and beneath the extensor tendons of the thumb. Lastly, this artery passes between the origins of the abductor indicis prior to its ultimate division. Through the fore arm two veins accompany the Radial artery, one lying on either side of it; and the anterior branch of the radial nerve lies on its outer side. The *branches* of the Radial are; 1. the *recurrent*, which is of considerable size, and which passes outwards and upwards between the two supinator muscles, and in front of the outer condyle, where it lies in the interval between the opposed margins of the supinator longus and brachialis anticus: it supplies these muscles and anastomoses with the superior profunda. 2. *Muscular* branches to the muscles of the fore arm: these are irregular in number and origin. 3. *Superficialis volæ*, which is given off a little above the wrist-joint, and crosses in front of the annular ligament and origin of the small muscles of the thumb, to join the palmar arch of arteries beneath the palmar fascia. 4. *Anterior carpal* branch crosses inwards beneath the flexor tendons to join a corresponding branch from the ulnar. 5. *Posterior carpal* holds a similar relation to the back of the carpus: it is larger than the last, and supplies the wrist-joint, and anastomoses with the dorsal branch of the ulnar and the interosseous arteries: branches also proceed from the above (or directly from the radial) to be distributed to the posterior interossei, between the metacarpal bones, and to anastomose with the deep palmar arch. 6. *Dorsales Pollicis*, two in number, supply either side of the dorsum of the thumb. 7. *Dorsalis indicis*, sometimes arising with the last, usually terminates by perforating the second interosseous space, and joining the superficial palmar arch. The ultimate branches of the radial are—8. *Princeps pollicis*, which passes to the palmar surface of the thumb between the abductor indicis and pollicis muscles, being placed on the ulnar side of its metacarpal bone, but at the metacarpo-phalangeal articulation dividing into two branches, which supply the ulnar and radial sides of the thumb, and anastomose at its extremity. 9. *Radialis indicis*, supplies the radial side of the index finger, communicating with the digital branch of the palmar arch. 10. *Palmaris profunda* crosses the palmar region towards its ulnar side, lying on the metacarpal bones and interossei muscles, and covered by the flexor tendons and lumbricales; the convexity of this arch is towards the fingers, and from it twigs are detached to supply the interrossei muscles, and communicate with the ulnar arch: it terminates by a free anastomosis with the deep communicating branch of the ulnar artery, opposite the metacarpal bone of the little finger.

*Arteria Ulnaris* takes a deeper course than the radial, being covered above by the pronator teres, flexor carpi radialis, palmaris longus, and flexor digitorum sublimis: in the middle third of the fore arm, it may be exposed by separating the last-named muscle from the adjoining edge of the flexor carpi ulnaris; and nearer to the wrist it is covered only by the fascia. Throughout this course the ulnar artery rests on the flexor digiturum profundus, except just after its separation from the radial, when it is in contact with the insertion of the brachialis anticus: in passing to the palm it runs superficial to the anterior annular ligament. Two veins accompany the artery, and the ulnar nerve lies to its ulnar side. The branches of the ulnar artery are—1. *Anterior recurrent*, which takes an arched course between the pronator teres and brachialis anticus to the front of the inner condyle, where, after supplying the above muscles, it anastomoses with the anastomotic artery. 2. *Posterior recurrent*, of much larger size, pierces the flexor carpi ulnaris to gain the posterior aspect of the inner condyle, where it is covered by the ulnar nerve: it supplies some muscular twigs, but is principally distributed to the elbow-joint, communicating freely with the three branches of the brachial. 3. The *Interosseous* branch passes backwards to the interosseous ligament, where it divides, after giving off a twig to accompany the median nerve. The anterior branch descends on the interosseous ligament, accompanied by a branch of the median nerve, and covered by some fibres of the adjoining origin of the flexor pollicis and profundus muscles: at the upper border of the pronator quadratus this artery subdivides, one branch supplying the above muscle, and communicating with the anterior carpal arteries, whilst the other perforates the interosseous membrane, and anastomoses with the posterior carpal branches. The posterior interosseal branch, after separating from the anterior, pierces the interosseous membrane, and divides under cover of the anconeus and long extensor muscle, into a recurrent branch, which ascends between the external condyle and olecranon to be distributed to the triceps, and to communicate with the other branches in this region; and a descending branch, which takes its course between the long extensor of the fingers and those of the thumb: these muscles receive their supply from it, and it ultimately communicates with the posterior carpal branches of the radial and ulnar arteries and posterior branch of the anterior interosseous. 4 and 5. *Anterior* and *posterior carpal* branches of the Ulnar artery are distributed as their names denote, and anastomose with those of the radial. Immediately after crossing the annular ligament of the wrist the Ulnar artery terminates by dividing into its ultimate branches, viz.:—6, the *communicating*, which passes backwards between the flexor brevis and abductor minimi digiti to join the deep palmar arch of arteries; and 7, the *superficial palmar arch*: the position of this arch is with its convexity looking downwards and inwards, its course being oblique, and its termination near the centre of the second metacarpal bone: it lies between the palmar fascia and the flexor tendons and median



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nerve. From the concavity of this arch several small twigs are detached to the palm; whilst from its convexity the digital branches arise: these are four in number: the first runs on the ulnar side of the little finger; the second and third supply the opposed margins of the little, ring and middle fingers; and the fourth the adjacent borders of the middle and index fingers: each branch therefore bifurcates, and they again unite in the form of an arch on the ungual phalanx of each finger, the last anastomosing with the radialis indicis. They are accompanied by corresponding branches of the median and ulnar nerves, which they usually perforate at the clefts between the fingers.

*Aorta Thoracica.*—The course of this division of the main arterial conduit has been already traced: its branches, which are numerous but not very considerable, are the following:—1. *Arteriæ Bronchiales*, irregular in number, origin, and size, are usually four, two for either lung. They arise from the aorta opposite the roots of the lungs, and divide prior to entering these organs, into the structure of which they accompany the bronchial tubes. 2. *Arteriæ Œsophageæ*, also irregular in number, arise at different points from the aorta, and are distributed to the œsophagus, communicating with other branches it receives. 3. *Arteriæ Intercostales* are usually nine pairs, and arise from the postero-lateral aspect of the aorta, those of the right side being the longer. The superior branches form an obtuse angle with the aorta at their origin, whilst that of the inferior is acute. Near the heads of the ribs these vessels divide into two branches; the posterior of which pass backwards close to the vertebræ, and are distributed to the spinal cord and muscles of the back: the anterior and larger branch of each runs in the groove of the corresponding rib between the layers of intercostal muscles, which are thus supplied. About the centre of each rib, this, the proper intercostal artery, divides into two branches, the inferior of which is lost on the rib below; the superior continues the same course as the trunk, and ultimately anastomoses with other branches about the chest. The accompanying intercostal vein and nerve lie superior to the artery.

*Branches of the Abdominal Aorta.*—In its progress through the abdomen the Aorta gives off several branches for the supply of the chylopoietic and urinary viscera; in addition to which the diaphragm, and the testicles and ovaries, respectively in the male and female, receive their arterial supply from the same source. These vessels (some of which are single and others in pairs) will be described in the order in which they arise from above downwards.

*Arteriæ Phrenicæ*, a pair, are detached from the anterior part of the Aorta whilst that vessel is still between the crura of the diaphragm. The course of each branch is outwards and forwards, that of the left side passing behind the œsophagus, and that of the right behind the vena cava. At the junction of the tendinous and fleshy portions of the diaphragm the phrenic arteries divide into an external branch, which is distributed to the circumference of the muscle, and an anterior branch, which takes a semicircular course to the xiphoid cartilage, distributing twigs in its progress; the former branch anastomoses with the intercostals, and the latter with its fellow and the internal mammary. The œsophagus, pancreas, supra-renal capsules, and semi-lunar ganglia of the sympathetic system also receive twigs from these arteries.

*Axis Cœlica.*—This short but large stem arises from the Aorta immediately below the last described, and opposite the junction of the dorsal and lumbar regions of the spine. At its origin this vessel has in front of it the stomach, the supra-renal capsule and semi-lunar ganglion, and it is surrounded by the branches of solar plexus. After a course of little more than half an inch, in which the axis is directed downwards, forwards, and to the left side, it divides into three branches, for the supply of the stomach, liver, and spleen. 1. The *Gastric* is the smallest of these branches: its direction is forwards, upwards, and to the left side, to gain the cardiac extremity of the stomach, where it divides. The ascending branch or branches constitute the smaller division of the vessel, and are distributed to the cardiac extremity of the stomach and to the œsophagus, anastomosing with the thoracic œsophageal branches and cardiac branches of the splenic. The larger division is directed along the smaller curvature of the stomach, between the laminæ of the gastro-hepatic omentum, towards the pylorus, where it terminates by communicating with the pyloric branch of the hepatic. In its progress this branch supplies both surfaces of the stomach, and anastomoses freely with the gastro-epiploic arteries. 2. The *Hepatic* is a large and important branch, and, from its destination, might with propriety be named gastro-hepatic. Its course is at first horizontal, between the pancreas and Spigelian lobe of the liver and behind the pylorus, and subsequently forwards, upwards, and towards the right side, to the transverse fissure of the liver. In this course it is enclosed between the layers of the gastro-hepatic omentum, and at its approach to the liver it lies to the left side of the hepatic duct and vena portæ. The branches of the hepatic artery are, *a.* superior pyloric, which is detached immediately above the pylorus, and is distributed to it and the pancreas, anastomosing with the gastric; *b.* Gastro-duodenal, arises immediately after the last, and insinuating itself between the upper part of the duodenum and the pancreas, here gives off the inferior pyloric twigs, and then subdivides; the smaller of the resulting branches is named the pancreatico-duodenal, which runs in the concavity of this intestine, and distributes its branches to it and the pancreas; it communicates with branches of the splenic and mesenteric in the pancreas. The other branch is the principal artery of the stomach, and is called the right gastro-epiploic. Its course is downwards and forwards to gain the convex margin of the stomach, along which it runs between the adherent laminæ of the great omentum towards its left extremity. In this course it distributes branches over the curvatures of the stomach and to the great omentum, and ultimately communicates freely with the left gastro-epiploic, a branch of the splenic. The Hepatic artery at last divides into a branch for either lobe of the liver. *c.* The right hepatic branch gives off the cystic artery which supplies the gall-bladder, and then enters the right extremity of the transverse fissure of the liver. *d.* The left hepatic branch enters the left extremity of the porta or transverse fissure, and is then distributed to the structure of this viscus.* 3. The *Splenic* is the largest of the three branches of the Cœliac axis in the adult. Its course is horizontal,

* For particulars respecting the course and ultimate distribution of the hepatic vessels, the reader is referred to the minute anatomy of the liver, p. 453.

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 flexuous, and towards the left hypochondrium. It is parallel to, and in connexion with, the superior and posterior part of the pancreas, and lies upon the left crus of the diaphragm and upper part of the left psoas muscle, having the stomach in front. The corresponding vein is parallel but inferior to the artery. In its progress the splenic artery gives off (*a.*) small branches to the pancreas; (*b.*) a large pancreatic branch, which accompanies the duct of the gland; (*c.*) short gastric branches, which traverse the interval between the laminæ of the gastro-splenic omentum to gain the cardiac extremity of the stomach, to which they are distributed, anastomosing with the gastric and epiploic arteries: the trunk lastly divides into (*d.*) five or six branches, which enter the fissure in the gastric surface of the spleen; and (*e.*) the gastro-epiploica sinistra, which is directed towards the left side along the convex or greater curvature of the stomach, to which and the omentum it distributes its branches, and anastomoses with the proper gastric artery and gastro-epiploic branch of the hepatic. Each of the above divisions of the cœliac axis is accompanied by branches of the solar plexus of nerves.

*Arteria Mesenterica superior*, is also a single trunk, and nearly equal in size to the last described, about a quarter of an inch below which it arises. Its course is long and curved, so that it forms an arch which looks downwards and to the left side. At first it has the pancreas and vena portæ in front, and then crosses the inferior transverse portion of the duodenum and left renal vein. It subsequently insinuates itself between the layers of the mesentery, and proceeds in a curved direction towards the right iliac fossa, having its accompanying vein to its right side. The branches of the superior mesenteric artery are derived from its concavity and convexity: the former supply the large intestine, and are three in number. 1. The *middle colic* is the first of these: it takes its course between the laminæ of the transverse meso-colon, and divides into two branches, which proceed to be distributed to the intestine, and to anastomose with the branches on either side of it. 2. *The right colic* presents a similar arrangement to the last branch, also dividing and inosculating with the neighbouring branches: it is distributed to the ascending colon, as the last is to the transverse arch. 3. *Ileo-colic* branch is the termination of the artery, and usually divides into three secondary branches, which anastomose on the right and left, and supply the termination of the small intestine and the cæcum. Thus a series of arches is formed by the anastomosis of these three arteries with one another; the first also communicating with the left colic branch of the inferior mesenteric. From the convexity of the large arch above described, all the branches for the supply of the small intestines come off: they are fifteen or twenty in number, and lie between the laminæ of the mesentery. By the anastomoses of these also, a series of secondary arches is formed, from which the supplying branches of the small intestines proceed; still, however, forming smaller arches in their progress, and prior to their ultimate arborescent distribution around the intestine.

*Arteriæ Capsulares*.—There are usually branches, supplying the supra-renal bodies, directly derived from the aorta, above the origin of the renal arteries: others also arise from the phrenic and renal vessels.

*Arteriæ Renales*.—These vessels arise between the mesenterics, and generally exceed them, and even the cœliac axis, in calibre. The origin of the two arteries does not in general exactly correspond; the right kidney being on a plane a little below the left; its artery also arises lower. Further, from the position of the aorta, the right Renal artery is necessarily longer than the left, having to pass behind the vena cava prior to reaching its destination. Usually the right Renal artery is behind its vein, but the left is superficial to it: as they approach the kidney, however, both veins generally cover their corresponding arteries, the dilated upper extremity of the ureter being behind and beneath them. Before entering the organs they supply, each Renal artery divides into four or more branches.*

*Arteriæ Spermaticæ* arise below the renal from the anterior part of the aorta: the right often arises from the corresponding renal. The course of these vessels is nearly vertical, but tortuous: in the male they pass to the internal abdominal ring, where they join the spermatic cord: in the female they are destined to supply the ovaries. In their progress both vessels cross the psoas muscle and ureter, the right also crossing obliquely the vena cava. Small branches are detached from these vessels in their course; but their ultimate destination in the male is to the epididymis and proper tubular or secreting structure of the testicle. In the female the Spermatic arteries insinuate themselves between the laminæ of the broad ligament of the uterus, and there divide into branches which supply the ovaries, uterus, Fallopian tubes, round ligament, and inguinal canal.

*Arteriæ Lumbales*.—These are generally five pairs of arteries, given off from the Aorta at right angles in the lumbar region, opposite the intervertebral substance between each two vertebræ. In their progress outwards these vessels pass behind the sympathetic nerves, and beneath the crura of the diaphragm and psoæ muscles. Their branches are, 1. Spinal, which enter the intervertebral foramina to be distributed to the cord and its theca, as well as to the bones: 2. posterior muscular, which traverse the interval between the several transverse processes, and are distributed to the lumbar mass of muscles: 3. the abdominal branches, which pass between the psoas and quadratus muscle, and, after supplying them, terminate by being distributed to the abdominal muscles, anastomosing with the intercostals, ilio-lumbar, circumflexa ilii, epigastric, and mammary arteries.

*Arteria Mesenterica inferior* arises from the left side of the aorta, a little above its bifurcation: it is smaller than the superior tery of the same name. Its course is downwards, and towards the left iliac fossa, and it divides into the following three branches; 1. *Left Colic* passes to the descending colon, where it subdivides into a superior branch, which meets the left division of the middle colic artery, and an inferior branch which communicates with the sigmoid: it is ultimately distributed to the descending colon: 2, the *sigmoid* branch passes to the left iliac portion of the colon, where it is similarly distributed: 3, the *superior Hæmorrhoidal* is the largest of these branches: it descends between the layers of the meso-rectum, along the posterior part of the rectum, to within a few inches of its extremity, where it divides and subdivides into branches which supply this gut: some smaller branches

* For the distribution of these vessels, see 'Kidney, Minute Anatomy of,' p. 468.

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are also detached before the above division: this artery communicates with the other hæmorrhoidal branches of the internal iliac and pudic.

*Arteria Sacra media* is the last branch of the aorta before its bifurcation, for it comes off from the angle of the fork between the two iliacs, and sometimes arises from the right iliac. It takes a vertical direction along the middle of the sacrum to the coccyx, dividing into branches which supply the rectum and muscles in this region, and communicate with the hæmorrhoidal and lateral sacral arteries.

*Arteriæ Iliacæ communes.*—These vessels result from an equal division of the Aorta on the body of the fourth lumbar vertebra, or the intervertebral substance between it and the fifth. The angle formed by the divergence of these arteries, as they descend, is acute; but less so in the female than the male, on account of the greater expanse of the pelvis in the former: opposite the sacro-iliac articulation they divide into external and internal iliac arteries. Each common Iliac artery has the psoas muscle externally, and is covered by peritoneum: the ureters cross them at their points of bifurcation. The right artery is further covered by the ileum just prior to its joining the cæcum; and the left is in like manner concealed by the commencement of the rectum. In consequence of the position of the Aorta, the right Iliac artery is a little longer than the left. The relation of these vessels to the corresponding veins is, that the artery of the right side crosses both the common iliac veins, and conceals them where they unite to form the inferior cava; whilst the left Iliac artery only overlaps the outer border of its corresponding vein. When these vessels give off branches prior to their bifurcation, they are very trivial and unimportant, being distributed to the ureter, peritoneum, &c.

*Arteria Iliaca interna.*—This, which was the larger of the two branches of the common Iliac in the fœtus, in consequence of its then forming the main conduit by which the blood flowed from the child to the placenta, is in the adult smaller than the branch destined for the lower extremity. The internal Iliac forms a curve which faces forwards, as it descends towards the great sciatic notch. It is covered by the pelvic viscera, and crossed superficially by the ureter and vas deferens: behind it lies the corresponding vein and lumbo-sacral nerve. The ligamentous remains of the hypogastric artery ascend from near its termination to the umbilicus, being usually pervious for a short distance, and giving off one of the vesical arteries. The branches of the internal Iliac are distributed to the pelvic viscera and parietes of this cavity; also to the organs of generation and to the thigh. 1. The *Glutæal* artery is the largest branch, and arises from the back part of the trunk deeply in the pelvis: it passes downwards and backwards through the great sciatic foramen between the bone and upper edge of the pyriform muscle, accompanied by its vein and the superior glutæal nerve; and under cover of the great glutæal muscle divides into a superficial and deep set of branches. Within the pelvis this artery is crossed by the lumbo-sacral nerve. 1. The course of the superficial branch of the glutæal artery is upwards and outwards between the glutæus medius and maximus muscles, in which its branches are partly distributed, the integuments of the sacral and glutæal regions receiving their supply from the same source; and branches anastomose with those of the sciatic and pudic arteries. 2. The deep branch is the larger, and directs itself upwards and forwards between the glutæus medius and minimus muscles: it supplies the nutritious artery to the ilium, and then subdivides into a superior set, which take an arched course towards the anterior superior spine of the ilium, following the circumference of the smallest glutæal muscle: the middle set take a direction towards the great trochanter: the inferior branch penetrates the glutæus minimus, and runs forwards above the capsule of the hip-joint to the anterior inferior spine of the ilium: the various muscles in this region and the capsule of the hip-joint are thus supplied; and the several branches communicate with the ilio-lumbar and circumflex arteries of the ilium and thigh. 3. The *Ischiatic* artery is somewhat smaller than the last, and takes a longer course within the pelvis before its exit. It crosses the pyriform muscle and sacral plexus, having the rectum internally: it then leaves the pelvis, in company with the pudic, by the greater sciatic hole, below the pyriform muscle, and makes its appearance in the interval between the great trochanter and tuberosity of the ischium, inclining in its descent to the inner side of the great sciatic nerve. After giving off some insignificant muscular and visceral branches within the pelvis, this artery divides into a coccygeal branch, which is directed inwards, and, after piercing the sacro-sciatic ligaments, is distributed to the neighbouring muscles, anastomosing with the sacral arteries. The muscular branches are considerable, and are distributed to the glutæal and posterior femoral regions, anastomosing with the circumflex and perforating arteries of the thigh. Lastly, the accompanying artery of the great sciatic nerve is derived from the ischiatic: it penetrates the nerve at variable distances down the thigh, and supplies it in its course and distribution. 4. The *Obturator* artery is very irregular in its origin, sometimes arising from the external iliac, but more frequently from its epigastric branch. When arising from the internal iliac, it comes from its anterior part, and takes a direction forwards and downwards to the upper part of the thyroid foramen: in this course it lies inferior but parallel to the external iliac vessels, and has its accompanying vein beneath it, and the obturator nerve above it. On entering the femoral region it lies between the pectinæus and obturator externus muscles, where it divides into its ultimate branches. The obturator artery gives off small twigs to the surrounding parts within the pelvis, and in the thigh divides into an anterior branch, which descends between the adductor longus and brevis muscles, and is distributed to this region, communicating principally with the internal circumflex artery; and a posterior branch which passes backwards and outwards between the obturator muscles and along the outer border of the obturator hole: the muscles about the hip-joint are thus in part supplied, and one or two branches enter the acetabulum at its notch, which are distributed to its contents, and likewise supply the head of the femur. 5. The *Pudic* artery arises from the internal iliac, close to, or in common with, the ischiatic, which vessel it accompanies out of the pelvis, lying internal and anterior to it, but otherwise having precisely the same relations. Immediately after their exit, the pudic artery winds round the spine of the ischium, and again enters the pelvis by the smaller ischiatic foramen: it subsequently ascends in an arched manner along the inside of the tuberosity and ramus of the ischium and ramus of the pubes to the under part

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of the Symphysis, where it divides into its terminating branches. In this course the artery lies in a groove formed by the attachment of the obturator fascia to the rami of the ischium and pubes, and at first has the internal obturator muscle between it and the bone. In its first division within the pelvis, and whilst on the spine of the ischium, the obturator artery gives off small visceral and muscular twigs; but its first branches of any importance are the external hæmorrhoidal, which pierce the obturator fascia, and are distributed to the extremity of the rectum, where they communicate with the other hæmorrhoidal arteries. The perineal branch arises next to the last described, and also pierces the obturator fascia close to the triangular ligament, by which means it gains the perineum: it crosses, superficial to the transverse perineal muscle, to the interval between the erector penis and accelerator urinæ, and in company with the nerve of the same name. This artery supplies the perineal muscles, and is ultimately lost in the component textures of the scrotum, where it anastomoses with twigs from the external pudic and spermatic arteries and from the femoral. In the female this branch is large, and supplies the labium. The transverse perineal branch frequently arises from the last, or from the pudic immediately after it: its course is transversely inwards between the bulb of the urethra and anus, and superficial to the transverse muscle; and it supplies the muscles, communicating with its fellow. The artery of the bulb is more considerable and important: it runs in the structure of the triangular ligament a quarter of an inch above its base, towards the bulb, where it divides into a small branch which supplies Cowper's gland, and a large one which penetrates the bulb, and is distributed to the spongy portion of the urethra. The pudic artery itself now pierces the triangular ligament close to the crus penis, immediately prior to its division into its ultimate branches. Of these the artery of the corpus cavernosum enters the crus, and distributes its branches to the cavernous body of the penis, communicating through the pectiniform septum with its fellow. The dorsal artery of the penis gains the back of the penis by ascending between its crus and the ramus of the pubes close to the symphysis, and then runs forwards close to its fellow in the groove between the crura penis, and under cover of the suspensory ligament and superficial fascia: at the corona glandis a free circular anastomosis takes place between the arteries of either side, and branches proceed to supply the glans and prepuce, and communicate with the ultimate twigs of the bulbous artery. A single vein accompanies and lies between the two arteries. The next two arteries supply the interior of the parietes of the pelvis: they are, 6. *The Ilio-lumbar*, which proceeds from the outer and back part of the internal iliac, and directs its course upwards, backwards, and outwards beneath the external iliac vessels and psoas muscle, where it divides: its external or iliac branches penetrate the iliacus muscle, which they supply, and then proceed to the crest of the ilium, where they communicate with twigs of the glutæal and circumflexa ilii arteries: others are lost in the abdominal muscles. The internal or lumbar branches of the ilio-lumbar artery are distributed to the lumbar and iliac muscles, and some twigs enter the lumbar foramina and supply the theca vertebralis: these branches anastomose most freely with the lumbar arteries. The ilium receives its nutritious artery from the iliac branch of the ilio-lumbar. 7. The *Lateral Sacral* artery arises close to (sometimes in common with) the last, from the inner side of the internal iliac: it inclines somewhat inwards as it descends on the anterior part of the sacrum, crossing in its progress the pyriform muscle and sacral plexus of nerves: its branches are distributed to the pelvic viscera and to the pyriform muscle; and the spinal cord receives twigs which penetrate the sacral foramina: it ultimately communicates freely with the middle sacral artery. The remaining branches of the internal iliac are distributed to the viscera, viz., 8. The *middle Hæmorrhoidal*, which supplies the middle portion of the rectum, and communicates freely with the superior and external arteries of this intestine: 9. The *Vesical*, which are irregular in number and origin: one regular branch accompanies the ureter to the inferior fundus of the bladder, and gives off the artery of the vas deferens. Two more branches are superadded in the female, viz., 10. the *Uterine*, which is peculiar from its tortuous nature: it runs to the side of the uterus between the folds of the broad ligament, supplying in its course the Fallopian tubes, ovaries, and vagina; and it ultimately terminates in the structure of the uterus, where its branches anastomose with those of the opposite side. 11. The *Vaginal* artery is distributed to the side of the vagina, and to the neighbouring parts of the other viscera. The last two arteries not infrequently arise from the pudic or some other branch of the internal iliac, instead of coming directly from the trunk.

*Arteria Iliaca externa* separates from the internal iliac at the sacro-iliac articulation, and descends forwards and outwards to the centre of the crural arch, after passing which it receives the name of femoral. In this course the external iliac artery is at first bound to the inner side of the psoas muscle by a thin layer of fascia, but subsequently it rests on the anterior and inner border of this muscle, having also the iliac fascia behind it: the anterior crural nerve is quite to its outer side, and its corresponding vein is internal and posterior to it above, but on the same plane below: the peritoneum covers the artery and vein. Some small muscular twigs are detached from the external Iliac for the supply of the psoas and iliacus muscles, but its only named branches are two;—1. The *Epigastric* artery arises a little above Poupart's ligament, and at first proceeds downwards, forwards, and inwards to a level with this ligament, and then upwards and inwards between the fascia transversalis and peritoneum to the inner border of the internal ring: in this course it is usually accompanied by two veins, and crosses the external iliac vein. At the internal ring it crosses in front of the vas deferens, which is here hooking round the artery in its progress from the inguinal canal into the abdomen: it then enters the sheath of the rectus, and ascends between it and the muscle, in the structure of which it ultimately terminates by anastomosing with the internal mammary and lower intercostal arteries. The branches of the epigastric are two or three spermatic to the coverings of the cord: others supply the integuments, muscles, and peritoneum: some cross twigs anastomose with those from the opposite side. 2. The *Circumflexa ilii* arises opposite to, or a little lower than, the last branch, and from the fore and outer part of the external Iliac artery. It first runs upwards and outwards to the anterior superior spine of the ilium, corresponding in its course to the line of junction of

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the transverse and iliac fasciæ: it then divides, and one branch is distributed to the abdominal muscles, whereas the other continues its course along the inner border of the crest of the ilium, giving off numerous twigs to the abdominal and iliac muscles, and ultimately anastomosing with the ilio-lumbar artery.

*Arteria Femoralis.*—This large vessel is the continuation of the external iliac through the upper two-thirds of the thigh. It commences at the crural arch, and takes a spiral direction from the anterior to the inner side of the limb, and lastly gains its posterior aspect under the title of popliteal artery. In this course the femoral artery is at first superficially placed, so as to be felt pulsating at the groin, but afterwards it has deeper relations. It lies in its progress through the upper third of the thigh upon the psoas magnus muscle, and then anterior to, but not in contact with, the pectineus and adductor brevis at their insertions; its own vein and the profunda vessels are here behind the artery: in the middle third it rests on the adductor longus. Above, the artery is covered by the integuments and fascia only, and has its vein to its inner side: the latter vessel soon inclines to the posterior aspect of the former. In the middle third of the thigh the artery lies behind the sartorius muscle and its sheath, having the adductor longus on its inner, and the vastus internus on its outer side; and lastly, it enters the tendinous canal formed by the dense fibrous connexion of these two muscles and the adductor magnus. The anterior crural nerve is separated from the artery above by some fibres of the psoas muscle; a long branch (the saphenus) accompanies the femoral artery, lying on its outer side; and others descend superficial to it. The first branches of the femoral are small but pretty regular: they are three in number, and emerge at the saphenic opening in the fascia lata.

1. The *superficial Epigastric* ascends over Poupart's ligament between the laminæ of the superficial fascia towards the umbilicus, and is distributed to the inguinal glands and abdominal integuments. 2. The *superficial Pudic* branch or branches pass to the integuments and cellular covering of the organs of generation above and below the spine of the pubes; the latter twigs anastomose with the perineal artery. 3. The *superficial Circumflexa ilii* runs along Poupart's ligament to the anterior spine of the ilium, and distributes its twigs in this region, communicating with the deep artery of the same name, and cutaneous branches of the glutæal. 4. The *Profunda* branch is the great artery of supply to the thigh: it arises from the outer and back part of the Femoral, about an inch and a half or two inches below Poupart's ligament, and at first crosses to the external aspect of this trunk, and here lies on the conjoined psoas and iliacus muscles: it then passes backwards and inwards across the cruræus and vastus internus, and descends parallel and posterior to the Femoral artery, separated from it by both venæ comites, and lying first upon the insertion of the pectineus and short adductor, and subsequently behind the tendon of the adductor longus, where its terminating branch is found perforating the adductor magnus to supply the hamstring muscles. The branches of the Profunda are the circumflex and perforating. (*a*.) The *external Circumflex* is usually the first branch, and is not infrequently derived directly from the Femoral. It comes off from the bend of the Profunda, and proceeds outwards between the sartorius and rectus muscles in front, and the psoas and iliacus behind, being surrounded by the divisions of the crural nerve: it divides into ascending branches, which are distributed to the tensor vaginæ femoris, sartorius, and smaller glutæal muscles, and which communicate with the circumflexa ilii and glutæal arteries: the middle or proper circumflex branches cross deeply in front of the cruræus, and pierce the vastus externus and tendon of the glutæus maximus, where they are distributed to the rotator muscles and hip-joint, and communicate with the sciatic, glutæal, and internal circumflex arteries. The descending branches are the longest and largest, and take their course behind the rectus and vastus externus, which muscles they supply, and then anastomose with the external articular arteries. (*b*) The *internal Circumflex* artery arises from the inner and back part of the profunda: it almost immediately crosses the tendon of the psoas and iliacus a little above the smaller trochanter, and then passes between the external obturator muscle above and the short adductor below: it is subsequently interposed between the adjoining margins of the quadratus and adductor magnus, where it is covered by the glutæus maximus. In this course the internal circumflex distributes branches to the adductor mass of muscles, some of which become cutaneous, and others communicate with the obturator. A small branch usually enters the acetabulum and supplies both surfaces of the articulation. The terminating branches of this artery are an ascending one, which is guided by the external obturator tendon to the trochanteric fossa, where it communicates with the glutæal and external circumflex; and a descending branch, which is distributed to the glutæal, adductor, and hamstring muscles, and communicates with the perforating and ischiatic arteries. (*c*.) The *superior perforating* artery arises from the back of the Profunda, and, passing beneath the lower border of the pectineus, pierces the adductor brevis and magnus, to supply the glutæal and hamstring muscles. (*d*.) The *middle perforating* artery also pierces the great and usually the small adductor, and is similarly distributed: it is generally the largest of the three, and also supplies the vastus externus muscle. (*e*.) The *inferior perforating* artery passes through the adductor magnus opposite the upper border of the long adductor, and supplies the hamstring muscles, and anastomoses with the muscular branches of the popliteal artery. 5. The great *Anastomotic branch* arises from the Femoral just before it enters the popliteal space, and, directing its course to the inner condyle, divides into branches which supply the vastus internus and cruræus muscles, and communicate with the external circumflex and inner articular arteries, where it helps to supply the articulation: this artery is accompanied round the knee by the great saphenus nerve.

*Arteria Poplitea.*—After penetrating the adductor magnus, as above described, the great artery of the lower limb receives the name of the space through which it passes, and occupies the posterior aspect of the thigh and leg: at the lower border of the popliteus muscle it bifurcates. The course of the popliteal artery is oblique, extending from the inner side of the ham above to its centre below. At first it is covered by the semi membranosus, but soon emerges, and then has only the fascia and integuments superficial to it: inferiorly, however, it is again covered by the converging heads of the gastrocnemius muscle. The anterior relations of the artery are, in succession, the femur, the

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ligament of Winslow, and the popliteus muscle. The popliteal vein is posterior to the artery, and a little to its outer side, and the popliteal nerves are still more superficial: of these the inner division crosses to the tibial side of both artery and vein below. The density of the popliteal fascia, and the adipose matter and glands in this region prevent the pulsation of the artery being felt so distinctly as might be anticipated. The following branches are derived from the popliteal artery:—1. *Superior muscular* branches, to the hemstring muscles. 2. *Inferior muscular* branches, to the gastrocnemius and soleus muscles. 3. *Superior internal articular*, which arises beneath the semi-membranosus, and winds above the inner condyle beneath the tendon of the great adductor: it is distriboted to the vastus internus and knee-joint, communicating above with the anastomotic artery. 4. *Superior external articular* takes a similar coorse over the outer condyle of the femor and beneath the biceps tendon; and it has a parallel distribotion. 5. *Inferior internal articular* is applied around the neck of the tibia, where it is covered by the inner lateral ligament of the knee-joint, and crossed by the three tendons which are here passing to their insertion: its distribution is to the joint. 6. *Inferior external articular* runs under cover of the outer head of the gastrocnemius, the plantaris, and external lateral ligament; it is subsequently applied upon the convex border of the outer semilunar cartilage, along which it runs to the patella: it is here distributed upwards and downwards, the lower twigs anastomosing with the recurrent tibial. 7. The *middle articular artery* pierces Winslow's ligament, and ramifies in the interior of the articulation. All these articular branches communicate more or less with each other around and in the knee-joint.

*Arteria Tibialis antica.*—This is the smaller of the two branches which result from the bifurcation of the popliteal trunk; and immediately after its separation it passes through the interosseoos space close to the neck of the fibula, in which coorse it penetrates some fibres of the posterior tibial muscle, and is accompanied by a small nerve. In the anterior tibial region this artery is first found lying between the tibialis anticus and exteosor digitorum; then between the former and extensor pollicis; and in the inferior third of the limb, between the last named (which overlaps it) and the common extensor of the toes. The artery is deeply seated above, being covered in by the muscles on either side of it, and resting on the interosseous ligament; but in the lower part of the limb it is more superficial, and rests on the anterior part of the tibia. On leaving the tibial region, the anterior tibial artery crosses beneath the annular ligament to the tarsus, lying in succession on the astragalus, navicular, and inner cuneiform bones, and having superficial to it the inner tendon of the short extensor; at the first interosseal space of the metatarsus the artery ultimately bifurcates. The venæ comites lie one on either side of the artery, and the anterior tibial nerve is superficial, and generally on its outer side.

The branches of the anterior tibial artery are—1. The *Recurrent*, which arises just after the artery has passed the interosseous space, and, after piercing the tibialis anticus, is distriboted to the anterior and ooter part of the knee-joint, communicating with the inferior articular branches. 2. The *muscular* branches arise at various points, and are distributed to the muscles in this region. 3. The *internal malleolar* branch arises a little above the base of the tibia, and, crossing beneath the tendon of the tibialis anticus, is distributed to the regioo whence it is named. 4. The *external malleolar* branch is larger, and, passing beneath the tendons of the commoo extensor and that of the great toe, supplies the outer malleolar region. 5. The *tarsal* branch passes outwards beneath the tendons on the dorsum of the foot, and is distributed to the short extensor muscle and tarsal articulations. 6. The *metatarsal* branch takes an arched course across the bases of the metatarsal bones, supplying them, and sending twigs forwards to the ooter three interosseal spaces: these anastomose with the plantar arteries, and supply the dorsal interossei muscles. The terminating branches are (7.), the *dorsal* artery of the great toe, which divides and supplies the tibial side of the great toe, and opposed margios of the first and second toes; and (8.) the *communicating* branch, which descends through the first metatarsal interosseous space to joio the termination of the external plantar artery.

*Arteria Tibialis postica* descends from the popliteus muscle, through the posterior tibial region, and between the superficial and deep layer of muscles, to the depression between the inner malleolus and heel, where it bifurcates. Through its whole course this artery is covered by the deep fascia of the leg, which, in fact, forms its only investment (in addition to the superficial fascia) in its inferior third, where the muscles leave it otherwise exposed. Io its upper third it rests on the tibialis posticus, in its middle third on the flexor digitorum, and lower down some cellular tissue alone separates it from the tibia; two venæ comites accompany the artery; and the posterior tibial nerve is usually external to it through the greater part of its course. At the ankle the above relation holds good, and the parts enumerated lie between the flexor digitorum anteriorly, and flexor pollicis posteriorly. The following are the branches of the posterior tibial:—1. *Muscular*, to the superficial and deep layers of muscles. 2. The *nutritious* artery, which enters by the foramen in the tibia for that purpose, and is distributed to its interior. 3. The *peroneal* artery arises from the posterior tibial about an inch below the popliteus muscle: it soon inclines outwards, and, piercing the tibialis posticus muscle, descends on the interosseous ligament close to the fibula, under cover of the flexor pollicis. In this course many muscular branches are detached, especially for the supply of the flexor pollicis and peronei: a considerable branch usually crosses transversely between the peroneal and posterior tibial arteries in the lower part of the leg. The terminating branches of the former are,—an anterior, which pierces the interosseous ligament a little above the ankle-joint, and on the back of the fibula anastomoses with the external malleolar artery; and a posterior branch, which descends behind the outer malleolus, and supplies the neighbouring muscles and the joint, communicating with the tarsal, metatarsal, and external plantar arteries. 4 and 5, the *plantar* arteries, are internal and external. Of these the former is much the smaller, and more simple in its distribution: it runs along the inner side of the sole of the foot, under cover of the abductor pollicis, giving off branches to supply the muscles of the great toe, and to anastomose with others from the anterior tibial; its ultimate branches are distributed to the integuments of the great toe. The external Plantar artery takes a long and flexuous course before it terminates at the base of the metatarsal bone of the great toe by junction with the



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anterior tibial. Its direction is first outwards and forwards towards the base of the metatarsal bone of the little toe, during which it lies between the flexor tendons and accessorius muscle above, and the short flexor of the toes and plantar fascia below: from this point it proceeds forwards a short distance (its most superficial position), and then extends across the metatarsal bones in the grooved interval between the transversalis pedis and adductor pollicis, lying above the long flexor tendons and lumbricales: the convexity of the arch thus formed is directed forwards and outwards. In the earlier part of its course the external plantar artery distributes twigs to the various adjoining muscles; but in its second division (properly called the *plantar arch*) the most important branches arise; they are the perforating and digital. Of these, the former supply the interossei, and communicate with the metatarsal branches of the anterior tibial; and the latter, which are four in number, supply severally the fibular side of the little toe, the opposed margins of the fourth and fifth, of the third and fourth, and of the second and third toes; in which distribution they are accompanied by the divisions of the plantar nerves, and they anastomose at the extremities of the phalanges. The opposed borders of the first and second toes are supplied, as already described, by the anterior tibial artery.

VENOUS SYSTEM (*das Venensystem*, Germ.; *le Système Veineux*, Fr.).

The blood from the various parts of the body (with the exception of the lungs) is ultimately collected into two large Veins, which are severally named the Vena Cava superior and Vena Cava inferior; and these both terminate in the right auricle of the heart. A particular description of the greater part of the venous branches which constitute these great trunks is superfluous, inasmuch as they for the most part accompany the corresponding arteries; there are, however, many superficial veins superadded which are unrelated altogether to the ramifications of the arterial system.

The veins which collect the blood from the head and neck are the *superficial* and *deep Jugular*. The superficial or *external Jugular* vein is formed by the junction of the temporal and internal maxillary veins, which takes place in the parotid gland; it thence passes downwards and backwards, crossing obliquely the sterno-mastoid muscle, but being almost parallel to the fibres of the platysma, by which it is covered, and ultimately joins the subclavian vein. In its progress through the neck, the superficial Jugular receives a branch from the facial, and the posterior auricular and cutaneous cervical veins; and usually communicates by one or more twigs with the internal Jugular. The deep or *internal Jugular* vein commences at the posterior lacerated foramen of the Skull, where the lateral sinus terminates:* it descends posterior and external to the Carotid artery, from which it is separated by the pneumogastric nerve, and terminates opposite the sternal extremity of the clavicle by joining the subclavian at a right angle. In its progress down the neck, the internal Jugular receives in succession the facial, lingual, pharyngeal, superior thyroid, and occipital veins; also the middle thyroid branches, and some small cutaneous veins from the neck. The veins of the diploë of the Skull terminate in the lateral sinuses, and in the frontal, deep temporal, and occipital veins.

* For the description of the sinuses, see 'Nervous System—Brain,' 437.

The Veins of the upper extremity are superficial and deep: of the former there are three. The *Cephalic* vein is first formed by radicle branches, which collect the blood from the outer and back part of the hand: it then ascends on the outer and anterior part of the fore arm, and opposite the elbow-joint is joined by the median cephalic: it thence proceeds in a vertical direction, on the outer and fore part of the upper arm, to the interval between the deltoid and great pectoral muscles, and ultimately sinks beneath the clavicle to join the axillary vein just before it becomes subclavian. The *Basilic* vein commences by a considerable branch (vena Salvatella) on the back of the last two metacarpal bones: it ascends along the ulnar side of the fore arm, and at the elbow is joined by the median basilic branch, and then continues its course along the inner side of the upper arm, receiving twigs and anastomosing with the cephalic in its progress. The Basilic is the largest vein of the arm, and ultimately becomes continuous with the axillary. The *Median* vein commences at the anterior part of the carpus, and terminates by division into the two branches already mentioned, and usually a third, which joins the deep veins. The *venæ comites* of the arteries are two in number to each: the brachial veins ultimately join the basilic to form the *Axillary* vein, which ascends in front of the artery to the subclavian space, receiving in its progress the circumflex, subscapular, and thoracic branches. The *Subclavian* vein is placed anterior and somewhat inferior to the corresponding artery, from which it is separated by the scalenus anticus muscle, the pneumogastric and phrenic nerves. The union of the subclavian and internal jugular veins of either side constitutes the *Venæ Innominatæ*. Of these veins the left is longer and more horizontal in its course, and usually larger than the right. The subclavian veins receive the vertebral, external jugular, and superior intercostal veins; the left bronchial vein terminating in the left superior intercostal, and the deep cervical joining the vertebral. In addition to the above, the subclavian of the left side receives the corresponding internal mammary and inferior thyroid veins; which branches on the right side terminate in the superior cava. The long vena innominata of the left side crosses the trachea and origin of the arteries from the arch of the aorta to a point opposite the cartilage of the right first rib, where it joins the corresponding shorter vein of the right side to form the—

*Vena Cava superior vel descendens.*—This great trunk descends, inclining a little forwards and to the left side, in front of the right pulmonary vessels, and enters the pericardium, the fibrous portion of which is prolonged on its surface. Within the pericardium it is surrounded by the serous membrane, and lies to the right of the aorta: it terminates in the posterior and upper part of the right auricle of the heart. Besides the two branches already noticed, the vena cava superior receives the *Vena Azygos*, just as it is entering the pericardium. This vein commences in the lumbar region just below the diaphragm, and, passing through the aortic opening of that muscle, continues its course through the posterior mediastinum to the right of the aorta and thoracic duct, and in front of the right intercostal arteries. In this course it receives the right intercostal and bronchial veins, and branches from the œsophagus: and lastly, a similar vein from the left side (azygos minor) crosses the spine about the fifth dorsal

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 vertebra to join it. The vena azygos then arches forwards around the root of the right lung and opposite the fourth dorsal vertebra, to terminate in the back part of the vena cava, as above described.

The superficial veins of the lower extremity are the *External* and *Internal Saphena*. The former of these ascends from the back and outer part of the foot, behind the external malleolus and superficial to the fascia, to the popliteal space, where it dips in between the heads of the gastrocnemius to join the popliteal vein. The internal saphena commences by radicles from the dorsum of the inner toes, and after communicating with the external ascends as a single trunk in front of the inner malleolus, and thence proceeds superficial to the fascia along the inner side of the leg, posterior to the inner condyle at the knee-joint, and subsequently along the inner and fore part of the thigh to the saphenic or falciform opening in the fascia lata, where it joins the femoral vein: in this progress it is joined by several smaller and one or two large branches, by which it is materially augmented in size; and in the thigh it is parallel, but on a plane a little internal, to the femoral artery.

The *Venæ comites* of the *tibial* and *peroneal* arteries (two to each) unite to form the *popliteal* vein, which lies superficial to the artery, inclining to its inner side below and to its outer side above. This large vein then accompanies the artery through the opening in the adductor magnus, and in the *femoral* region lies first on its posterior aspect and subsequently quite to its inner side. At the crural arch the femoral vein is interposed between the artery and crural ring. Each *external Iliac* vein lies to the inner and posterior part of the corresponding artery, and at the sacro-iliac articulation joins the *internal Iliac* to form the *common Iliac* vein. Of this large pair of vessels the left is the longer, and though on a plane posterior to the common iliac-artery of the same side, it lies almost entirely internal to it: the right vein is behind the corresponding artery, by which latter vessel the angular union of the two common Iliac veins is concealed.

The *Vena Cava inferior vel ascendens* is of larger calibre than the superior, and extends from the fourth or fifth lumbar vertebra to the heart. In its progress through the abdomen it lies on the bodies of the vertebræ, to the right of the median line and of the aorta, and in front of the right psoas muscle and crus of the diaphragm, as well as of the right renal artery and capsule: the peritoneum and small intestines lie anterior to it, and the perpendicular division of the duodenum is in direct contact with its anterior surface. Having arrived at the liver, it passes through a groove (sometimes a canal) between the right and Spigelian lobes, then penetrates the tendinous portion of the diaphragm and contiguous part of the pericardium, and terminates in the lower and back part of the right auricle. In this course it receives in succession the middle sacral vein, the four pair of lumbar veins, the right spermatic, the renal, the supra-renal, the hepatic, and phrenic veins. Of these, three only will require a separate notice. The *Spermatic* veins differ in their origin in the male and female, as the arteries differ in their distribution; and that of the left side terminates in the corresponding renal vein. Of the renal or emulgent veins the left is the longer, and crosses the aorta superficially: each commences by several large branches, which leave the kidney usually anterior and superior to the arteries and ureter. The *Hepatic* veins collect  the blood from the right, left, and Spigelian lobes of the liver, and terminate in the vena Cava just before it pierces the diaphragm.

The *Vertebral* canal presents *Sinuses* similar in character to those of the skull (with which they have no communication), and which extend from the occipital foramen to the extremity of the sacrum, between the theca vertebralis and bodies of the vertebræ, lying on either side of the posterior common ligament: they anastomose by transverse branches with each other; and further communicate with the internal jugular, vertebral, intercostal, and lumbar veins: they receive small veins from the cancellated structure of the vertebræ and from the dura mater of the canal. The *Spinal* veins accompany the arteries of the cord, and terminate in the inferior cerebellar veins.

The *great Coronary* vein ascends from the apex of the heart along the anterior fissure, in company with a branch of the right coronary artery, from which it separates at the base of the ventricles, and takes a direction to the left side, and proceeds along the groove between the left ventricle and auricle: in its progress it collects the blood from the different cavities of the heart, and is a good deal dilated just before it opens into the posterior and inferior part of the right auricle. Other and smaller cardiac veins open separately into the right auricle; but they are not sufficiently important or regular to deserve a particular description.

The *Vena Portæ* collects the blood from all the chylopoietic viscera, and conveys it to the liver. The two large trunks which by their convergence form the vena portæ are the following:—The *Splenic* vein commences by six or eight branches in the spleen; these unite to form a single trunk which accompanies the corresponding artery (beneath which it lies) along the posterior aspect of the pancreas to its right extremity; in this course it receives the *cardiac*, *gastro-epiploic*, and *coronary* veins of the stomach; the *duodenal*, *pancreatic*, and (usually) the *inferior mesenteric* veins. The *superior Mesenteric* vein corresponds to the artery of the same name in its course and distribution: it ultimately joins the splenic vein at a right angle behind the right extremity of the pancreas. The trunk of the portal vein results from this union: its length is about four inches, and it extends upwards and to the right side beneath the middle portion of the duodenum, and in front of the aorta: it then insinuates itself between the layers of the lesser omentum, lying behind and between the hepatic artery and duct, and receiving small branches from the omentum and gall-bladder. At the transverse fissure of the liver, the vena portæ divides into right and left branches, which accompany the corresponding arteries into either lobe of this organ, and receive in common with them an investment from the capsule of Glisson. Of this division the left branch is the longer and smaller: it supplies the Spigelian lobe, and runs horizontally as far as the obliterated umbilical vein before it enters the left lobe of the liver.

CAPILLARY SYSTEM (*Die Haargefässe*, Germ.; *le Système Capillaire*, Fr.)

The anatomy of this system is comprised in but few words. The vessels which constitute it are presumed to exist in every part of the body: they are of equal diameter throughout: they communicate freely and frequently with each other; and they are probably



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*Structure and Functions of the Blood-vessels.*—The offices of the three divisions of the circulating system of vessels, the anatomy of which has been just considered, may be simply summed up under the following heads:—The *Arteries* are the conduits which convey the blood to all parts of the system; the *Capillaries* receive this blood, and through and by them the various processes which in the aggregate constitute Assimilation are accomplished; the *Veins* receive the blood from the capillaries, and convey it back to the heart, for it to undergo purification in the lungs. It is apparent, therefore, that however insignificant this middle system may be in an anatomical or surgical point of view, it is of far higher interest and importance as associated with physiology than either the arterial or venous systems.

The characteristics of an *Artery* are, that it is a cylindrical tube of a yellowish colour, and possessing a considerable amount of elasticity. The erteries nearest to the beart are the largest and also the thickest: the Pulmonary artery is less dense than the Aorta. The importance of these vessels requires that every care should be taken of them in their progress to their destination: the large trunks are accordingly found imbedded in muscles, or situated in the concavity of joints, and on the inside of the limbs. The primary branches and their offsets are separated at different angles, which are determined generally according to the distance of the parts to be supplied: the force of the circulation is thus in a measure equalized. The inosculation between arteries takes place in three different ways,—either in the form of an arch, by straight branches, or by the union of two into one: these communications are of great importance to the preservation of the integrity of the circulation in case of interruption from any obstruction: the arterial circle in the brain illustrates the above point. Arteries are tortuous for various purposes: thus the dilatation of organs, such as the uterus, bladder, lips, and cheeks is permitted: but there are probably other and more important ends attained by this arrangement, which will be presently noticed. The amount of arterial supply to different structures is proportioned to their importance and peculiar functions; thus the brain, glands, and all secreting organs, growing parts, &c., are highly organized, whilst in some textures, such as cartilage and tendon, few or no vessels can be traced. Arteries possess three *Coats*,—an external or cellular, a middle or proper elastic coat, and an internal or serous lining. The first of these consists of a compact layer of oblique fibres, pale and firm, and closely interwoven; the middle tunic is composed of fibres placed transversely in relation to the length of the vessel, and each forming an incomplete segment of a circle; in the larger arteries this is highly elastic:* on the contrary, the internal coat is inelastic and brittle, being a continuous membrane without fibres, which is dense and semi-transparent. The arteries receive their own supply of blood usually through offsets from muscular branches; and the nervous supply is derived from the sympathetic system.

The structure of the *Veins* constitutes a remarkable contrast to that of the arteries, and indicates that they are little else than passive tubes, along which the blood passes in its progress from all parts of the system to the heart. They have but two coats, which correspond with the outer and inner tunics of arteries;* hence they are thinner and less elastic, but they are also tougher and more distensible than those vessels. The external coat is further absent in some parts, as in the sinuses of the brain, and in bones. One remarkable peculiarity in veins is the existence of valves, the use of which is to prevent the retrograde course of the blood, especially under muscular compression: they consist of a reduplication of the lining membrane, with a thin layer of intervening tendinous structure. These valves are not, however, universally present, but are wanting in the cerebral, pulmonary, internal jugular and portal veins; neither are they found in either of the two great venous trunks, nor in any the diameter of which is less than a line: they are more needed and therefore more numerous where the blood moves against gravity, and are relatively more frequent in the superficial than the deep veins. These valves, which in construction and action are precisely similar to the semilunar valves of the aorta, consist generally of two folds, placed opposite to each other, with their free edges towards the heart; but sometimes there is only one fold, or there may be three, or even four. The capacity of the venous system greatly exceeds that of the arterial, there being often two veins to one artery, independently of the superaddition of the superficial veins. The inosculations in the venous system are more frequent than in the arterial,—a point which is rendered essential by their superficial position and thinness, which renders them more obnoxious to compression: exercise, however, is necessary to facilitate the healthy circulation through the veins, which is not effected, as in the arteries, by jets, but the blood flows evenly and uninterruptedly through them.

The *Capillaries* are now justly regarded as an independent set of vessels, forming the connecting link between the arteries and veins. They are the vessels by which the actual processes of secretion, growth, and reproduction are carried on: they are of nearly equal calibre throughout, and anastomose very freely; and the blood moves through them slowly and evenly. Dr. Wedemeyer has suggested that the capillary circulation is not conducted by means of actual vessels, but that the arteries terminate in canals, which are, as it were, worn in the substance of the different tissues.

There is much temptation for speculation in discussing how the circulation through the different sets of vessels is performed; and physiologists are by no means agreed as to the extent or even nature of the forces which are called into operation. One point is clear, that the impulse of the circulation is in a great degree attributable to the direct action of the heart, for the jet of blood is synchronous with the contraction of the ventricles. Moreover, we can probably form but an imperfect estimate of the facility with which the blood circulates, by its appearance after removal from the vessels: its then viscidity may be incompatible with life and circulation; and it is more than probable that the vitality of the blood and vessels exercise a mutual influence on each other. Indeed, Sir Charles Bell† ingeniously suggests that the universal attraction between

* For further particulars, see 'Vascular Tissue,' and 'Elastic Tissue,' p. 253.

* The large veins near the heart offer an exception to this rule: here thin irregular fibres are interposed between the two coats, which probably only augment the strength and resistance of the vessels in this position.

† In his pamphlet, *On the Forces which Circulate the Blood.*

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solids and fluids is suspended in the vessels of a living body, and resumed on the occurrence of injury or death; and thus vast resistance is overcome by annihilation instead of accumulation of force, which is more consistent with the delicate texture of our frames. But is the heart's action alone sufficient (without *active* assistance from the arteries) to propel the blood into the capillaries? Opposite opinions have been espoused by different physiologists respecting this point. Mr. Huoter, who advocated the muscularity of arteries, performed several experiments to illustrate the subject: he divided a large artery, and found the stream of blood gradually cease as the artery contracted: and in another instance he bled a horse to death to procure as much contraction of the arteries as possible, and after death he removed a portion of the aorta, which he slit up and measured: after forcibly stretching it in its breadth, he found that it did not contract to its former dimensions. Sir G. Bell's observations* on tortuous arteries also bear importantly on the subject. He observes that those arteries which carry blood downwards have less curvature than those which carry it against gravity. Again, arteries going to growing tumors are tortuous, as are also those of the active mamma, and of the uterus during gestation. In establishing collateral circulation, arteries become tortuous as well as enlarged, which is not the case in those of an amputated limb. The evidences of partial excitement in the vascular system may be explained by assigning to arteries the property of exercising an independent action. The conclusions which Sir C. Bell labours to establish from the above facts are these: if arteries be muscular, those which are tortuous must of course possess more muscular fibres than those which are straight, and be more independent of the heart's action: further, this tortuosity increasing as they recede from the heart, they of course become more directly identified with, and under the control of, the organ they supply; and so, when not excited, a tortuous artery may retard, and when stimulated it may accelerate, the flow of blood. This hypothesis seems to be countenanced by the anatomical fact that organs, the activity of which is occasional or remitted (as the uterus, testicle, and spleen), possess tortuous arteries: and it may be added, that arteries almost uniformly become more flexuous as they approach their destination. On the other side, it may be remarked that the middle coat of an artery (the only possible seat of active contractility) possesses neither the physical nor chemical characters of muscular fibre: it is very elastic and destitute of fibrin. The property of contracting after extension is possessed by arteries after death; and no action is produced by the agency of mechanical stimuli or galvanism: but it must be remembered that muscular contractility does not survive (except for a limited period) the life of a part. Probably the true solution of this problem is after all to be found in ascribing elastic properties alone to the arteries near the heart; whilst to those of small calibre, which are removed to a distance from its influence, an amount of muscularity may be conceded, which may be supposed to bear a direct proportion to the extension of the circle in which they are found. In returning the blood to the heart through the veins, several causes appear to operate concurrently: these are, the influence of the heart and arteries constituting a "vis a tergo;" the tendency to a vacuum in the chest, aided probably by external atmospheric pressure, during inspiration; the heart's sorbent power, as apparently proved by experiment. In assigning to each of these causes their due influence, the important fact must not be lost sight of, that the valves in the veins prevent any reflux of the blood;—a point which is further illustrated by the agency of muscular compression in accelerating the venous circulation. It has been observed that during contraction of the auricles the great veins fill, and during dilatation that the distension is diminished: certainly the latter condition may be remarked at each inspiration in the cerebral sinuses when the skull is laid open. The circulation through the capillaries is uniformly regular and even, when undisturbed by any exciting cause: in them probably the partially expended force which drives the blood through the arteries on the one hand, and the new forces brought into operation in the venous circulation on the other, jointly concur in producing this effect.

The *Pulse* may be defined as that impulse which is produced in elastic cylinders by the active contraction of a muscular organ,—in fact, such apparatus as is presented by the heart and arteries in the relation they hold to each other: this impulse immediately succeeds the contraction of the left ventricle, although the interval is so trifling as to be imperceptible in arteries near the heart. The impression of dilatation which is conveyed to the finger when placed on a beating artery is erroneous, at any rate in degree; for experiment has proved that the calibre of an arterial trunk is augmented to a very inappreciable extent; but these vessels are very elastic longitudinally, and the sensation produced by the pulse is principally attributable to their tendency to extend themselves in this direction. The rapidity of the pulse differs at various periods of life: in new-born infants it is about 140; at the end of the first year, about 120; at the fourth year, 90; at puberty, 80; in manhood, 75; and later in life it becomes slower. It is quicker in small than in large animals; in horses it is about 40, but in a small dog it is difficult to count: it is rather quicker in women than in men. The rapidity of the pulse is increased by stimulants, such as wine, warmth, &c.; but continued cold depresses the heart's action. The varying character of the pulse is dependent on, and indicative of, corresponding conditions and changes in the action of the heart: a knowledge of these is, therefore, of great value to the medical practitioner. It has been calculated that the whole mass of the blood in an adult exceeds thirty pounds, which occupies between two and three minutes in its passage through the heart.

* *Op. Cit.*

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## SECTION VII.

### ORGANS OF RESPIRATION.



Under the above head are to be included the air-tube, consisting of the larynx, trachea and bronchi, and the lungs: but as a particular description of the larynx has been already given,* a brief recapitulation of its anatomy is all that will be necessary in the present section. The form, development, and organization of this division of the *air-tube* characterize it as designed to fulfil the two-fold function of an organ of respiration and voice. It consists of an expanded cartilage (the thyroid), the two plates of which are united at an angle in front, but widely separated behind: below this is an annular cartilage (the cricoid), which is broad behind and narrow anteriorly. This again is surmounted by a pair of moveable cartilages (the arytenoid), which are bound by strong elastic ligaments (chordæ vocales) to the posterior angular portion of the thyroid cartilage. Strong elastic membranes further connect the thyroid and cricoid cartilages in front, and the latter to the first ring of the trachea; and a further development of similar tissue unites the thyroid cartilage and os hyoides, which in its turn is attached by round ligaments to the styloid processes of the temporal bones. The epiglottis surmounts the glottis or upper orifice of the larynx, and is connected partly by fibrous tissue, but principally by reflections of the mucous membrane, to the notch in the upper edge of the thyroid cartilage, to the os hyoides and base of the tongue, and to the arytenoid cartilages. An appropriate muscular apparatus performs the various motions of elevation and depression of the larynx, as well as of contraction and dilatation of the rima glottidis, and modification of the tension of the chordæ vocales. The anterior and lateral parts of the larynx are embraced by a body of a soft and spongy character, and reddish-brown colour, known under the title of *Thyroid gland*: it is convex in front, and consists of two oval lobes, connected anteriorly by a transverse band, which lie on the lower part of the larynx and upper rings of the trachea; posteriorly and laterally it is in connexion with the carotid sheath and its contents. This organ varies much in dimensions: it has no duct, and its title to be called a gland is more than questionable: its function is not understood. The *Trachea* extends from the larynx to the bronchi, and consists of a series of fibro-cartilages (about eighteen or twenty in number), which, though annular in form, are incomplete, each constituting about three-fourths of a circle, the posterior fourth being occupied by a fibrous membrane, which is continued around, and in the interval between, the tracheal rings. The fibro-cartilages are flattened, and vary in their diameter; but the calibre of the tube itself is the same throughout. The outer membrane is studded with glands, which open by small ducts upon the surface of the mucous membrane: this latter is continuous with the lining membrane of the mouth, and extends through all the ramifications of the bronchi. The following are the relations of the trachea to surrounding parts: it is partially covered in the neck by the thyroid body, the sterno-hyoid and thyroid muscles, and the inferior thyroid veins: in the chest it lies posterior to the arch of the aorta, the arteria innominata and left vena innominata: its membranous portion rests upon the œsophagus; and it has on either side of it the carotid sheath and its contents. Opposite the second or third dorsal vertebra, the trachea divides into the right and left bronchus. Of these the right is larger and shorter, and its course is more horizontal than that of the left: the former is related to the curve of the vena azygos, and the latter passes obliquely downwards, and to the left side through the arch of the aorta to the left lung. Each bronchial tube divides, and the lower division of that destined for the right lung gives off a branch to its middle lobe. This binary arrangement is continued through five or six subdivisions, until ultimately the tubes diminish to capillary dimensions, and terminate in the air-vesicles. The bronchi and their earlier ramifications are similarly constituted to the trachea.

The *Lungs* occupy the lateral divisions of the thorax, and correspond in form to the containing cavity; that is, they are conical, with their base below and apex above. The varying dimensions of the thorax being constantly accompanied by proportionate distension of the lungs, it necessarily follows that these organs at all times accurately fill the chest: they are surrounded by a serous membrane to be presently described, and are separated by the heart, which occupies the middle mediastinum. The colour of the Lungs varies at different periods of life, and under different circumstances: in the adult they are of a bluish-grey tint, and mottled with darker patches, which latter are more apparent later in life: in the young the tint is of a brighter and more pink character. These organs are not symmetrical, the points of difference being attributable to the position of the liver on the right side, and the inclination of the heart to the left. Externally the Lungs are convex, and internally slightly concave, where they correspond to the pericardium: their anterior margin is sharp, and notched opposite the apex of the heart on the left side; but their posterior margin is obtuse and rounded, corresponding to the furrow on each side of the spine: their base is slightly concave, and rests on the convexity of the diaphragm; and their summit is obtuse but narrow, and rises a little above the level of the first rib. Each Lung is divided by a deep fissure into two lobes: it descends from behind the summit of the organ obliquely downwards and forwards, and ends in front of the base; by which

* See 'Muscular System,' p. 414.



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 arrangement the superior lobe is also the anterior of the two. The following are the points of contrast between the two Lungs:—the right is shorter but broader than the left, and generally rises a little higher in the neck: it is further subdivided by the presence of a second fissure, which extends from the great one forwards and downwards, and thus cuts off a middle lobe from the superior: this fissure is comparatively shallow, and the resulting lobe is triangular in form, with its base outwards. The root of each Lung is situated a little above its centre internally, and nearer to its posterior than its anterior aspect: its chief constituents are the bronchus, pulmonary artery, and veins: on both sides the pulmonary veins are placed inferior and anterior to the artery and bronchus, the latter being as regularly posterior to the artery; and the only difference between the two sides being, that on the left the bronchial tube is inferior to the artery, whereas the reverse is the case on the right. In addition to the above, the bronchial arteries and veins, branches of the pulmonary plexus of nerves, and lymphatics constitute a part of the root of each lung. The *Pleuræ* are a pair of serous membranes which invest the lungs, and are reflected on the inner surface of the containing cavity: each is a shut sac, and exhales the usual halitus secreted by serous membranes. In tracing either pleura, it is found to direct itself over the ribs and intercostal muscles to the side of the spine, where it forms the side of the posterior mediastinum: it is thence reflected on the posterior part of the pericardium, from which it passes to the back of the root of the lung, and is by it conducted to the lung itself, which it completely invests, sending down processes into the fissures: from the lung it extends along the upper surface of its root to the side and fore part of the pericardium, to which it adheres, and from which it is reflected to the back of the sternum, forming the lateral boundaries of the anterior mediastinum, and becoming here continuous with the line of reflexion with which the description was commenced. Superiorly, each pleura presents a cul-de-sac corresponding to the summit of the lung; and inferiorly, it is expanded over the thoracic surface of the diaphragm: a separate reflexion from the lower edge of the root of the lung to this muscle is called the broad ligament of the lung.

The *Mediastina* result from the arrangement of the two pleuræ in relation to each other and to the contents of the central division of the chest. The *anterior* mediastinum is immediately behind the sternum, in front of the pericardium, and between the pleuræ: it is narrow in the centre where the serous membranes are most nearly approximated, and expanded above and below: the direction of the pericardium causes a corresponding inclination of this space to the left side below: its contents are the sterno-hyoid and thyroid muscles at their origins, also the triangularis sterni and remains of the thymus gland. The *middle* mediastinum contains the heart and pericardium: and the *posterior*, which has its base at the spine, and is bounded in front by the pericardium, contains the œsophagus, aorta, vena azygos, thoracic duct, and the eighth and splanchnic nerves.

### *Structure and Physiology of the Organs of Respiration.*

As the lungs possess all the ordinary constituents, and perform the usual functions of secreting organs, they may be fairly placed in the same category with true glands: their secretion is carbonic acid, and their common duct the trachea. In examining the structure of the air-tubes, both trachea and bronchi, a tissue closely allied to the muscular is perceptible: this, according to the investigations of recent inquirers, and from late experiments, appears to be actual muscle, though belonging to the unstriped variety; and it may be traced through the bronchial ramifications "as far as the air-cells themselves, though not into them." it is further asserted that these fibres may be excited to contraction by the galvanic stimulus.* As the bronchial ramifications diminish in calibre, their rings gradually lose their annular form, and degenerate into irregular lamellæ dispersed over the canal: but still there is perceptible a peculiar elaboration, which retains the annular form at the different points of division, by which the tube is strengthened and kept from collapsing. These ramifications ultimately become purely membranous, and terminate in the air-cells, upon the surface and in the interstices of which the capillary network of the pulmonary arteries and veins ramify. The clusters of air-cells do not communicate with each other, but open into their appropriate bronchial capillaries; and the arterial and venous network on their surface is very close, the diameter of the vesicle exceeding about twenty times that of the capillary artery which is distributed upon it. The object of the above arrangement is, as in many other secreting organs, to obtain a large surface for the circulation of the blood in as compact a form as possible. The other constituents of the lungs, in addition to the bronchi and pulmonary vessels, are the bronchial or nutritious arteries and their corresponding veins; the nerves derived from the pulmonary plexus, consisting of mingled filaments of the sympathetic and paria vaga; and the lymphatics;—all of which are connected and held together by a quantity of cellular tissue. The following points remain for consideration, and constitute the physiological division of this section: 1, the act of respiration; 2, the changes which the air undergoes in the lungs; 3, the changes effected in the blood by its circulation through the lungs.

The act of *inspiration* is essentially muscular, and under usual circumstances performed by the agency of the diaphragm and intercostal muscles; the former elongating, and the latter expanding the thoracic cavity. Ordinary *expiration* is independent of muscular action, resulting from the elasticity of the thoracic parietes during the state of rest which succeeds the inspiratory effort. Many muscles, however, co-operate in producing what is termed forced respiration; thus, the pectoral and serrated muscles act directly upon the ribs in forced inspiration, as the triangular sternal and abdominal muscles do in expiration. Further, the aid of other muscles, whose agency is indirect, is called into operation in fixing the moveable insertions of the inspiratory muscles above enumerated; such are the trapezii, sterno-mastoidei, &c. In the act of inspiration the lungs themselves are perfectly passive; but experiment renders it probable that they have some share in expelling the air with which they are distended, a property which is most likely due to the muscularity of the bronchial ramifications already alluded to. The result of augmenting the capacity of the thorax is to

* Todd and Bowman's *Physiology*, p. 162. J. C. Williams, M.D., *On Diseases of the Chest.* Appendix.

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produce a tendency to a vacuum, which the air rushes in to occupy: it is admitted by both nasal and oral apertures; and the reason why it does not find its way into the pharynx is, that there is no such tendency to a vacuum in that direction, but that, on the contrary, the stomach is compressed and the œsophageal opening in the diaphragm contracted during the descent of that muscle. Amongst the forced acts of respiration may be enumerated the following: *coughing*, which is effected by spasmodic contraction of the abdominal muscles supervening on temporary closure of the glottis; the usual cause being irritation in the air passages, which is reflected from the spinal cord to the glottis and abdominal muscles. *Sneezing* is usually preceded by a deep inspiration, but is in itself an act of violent expiration: the cause in this instance is originally propagated from the nares, and the explosive effect is consequent on previous closure of the glottis, and of the posterior nares by approximation of the posterior arches of the palate and retro-pressure of the tongue. *Hiccough*, on the contrary, is a spasmodic inspiratory movement, the contraction of the diaphragm being arrested by the sudden closure of the glottis. *Yawning* is an example of the alternate acts of protracted inspiration and expiration, combined with corresponding affection of the respiratory muscles of the face: it is difficult to assign a proximate cause for this phenomenon. Although an act of volition may arrest, prolong, or otherwise control the respiratory movements, ordinary respiration is essentially an excited act, the nervous centre which receives and propagates the appropriate impression being the medulla oblongata: the excitant is the carbonic acid in the lungs; the centripetal nerve being the par vagum, and the phrenic that which conveys the impression to the diaphragm. The first act of inspiration is attributed by Dr. M. Hall to the impression made on the cutaneous nerves, by the change of temperature to which the fœtus is exposed immediately after birth.*

*Changes in the Air.*—In relation to respiration, gases may be divided into those which are respirable and support life; those which are positively destructive of life; and those which are only negatively so, by being useless: nitrogen ranks among the last; by it the oxygen is diluted so as to be rendered respirable. The proportions of these two gases in atmospheric air is 79 to 21; the mean quantity of carbonic acid gas in pure air being about four parts in 10,000 volumes. The prominent change which takes place in the respired air is the loss of oxygen and substitution of carbonic acid gas. As regards the nitrogen, experimenters have obtained different results, but most seem to agree in the belief that this gas is both absorbed and exhaled during respiration; and the loss or increase, if any, is but trifling, though varying according to circumstances. The locality and mode of generation of carbonic acid gas has been the subject of repeated experiment and conjecture, for the results alone of which the limits of the present Article will afford space. At each expiration a certain amount of watery vapour is exhaled, which, in round numbers, and taking the mean result of many experiments, may be stated at about sixteen ounces in the twenty-four hours, in an adult: the origin of this vapour was formerly attributed to the combination of the oxygen of the air with the hydrogen of the blood. According to Allen and Pepys, air, once respired, contains about eight per cent. of carbonic acid, which is more than has been obtained by other experimenters: the quantity of pure carbon thus removed from the blood in twenty-four hours would amount to nearly eleven ounces, which Berzelius shows to be improbable from an estimate of the large proportion of solid food that would be requisite to supply anything like this quantity. It has been observed that oxygen disappears, and that carbonic acid is generated in respiration; now, the quantity of the latter which is expired does not account for the amount of oxygen which is consumed, the deficiency varying, according to the results obtained by different experimenters, from one-third to one-tenth, and being much greater in herbivorous than carnivorous animals. All the oxygen respired is not consumed at the first inspiration, but as much as thirteen of the twenty-one parts contained in one hundred cubic inches of atmospheric air are returned. Further, a diminution in the gross bulk of the inspired air is universally admitted, and is doubtless to be accounted for, at least in part, by the condensation consequent on the union of the carbon and oxygen: the mean of the estimates which have been made of this decrease is about $\frac{1}{74}$th of the volume of the air inspired.

*Changes in the Blood.*—The changes which the blood undergoes by exposure to the air in the lungs may be imitated by admixture with oxygen, as by exposure in a vessel after being withdrawn from the body: the addition of carbonic acid gas blackens it, whilst oxygen renders it a bright scarlet. The specific gravity of purple venous blood rather exceeds that of arterial, being, according to Dr. J. Davy, in the proportion of 1050 to 1047; the latter also differs from the former in being from 1° to 1½° higher in temperature. The further point of contrast noticed by different observers are, that arterial blood coagulates more quickly and contains more fibrin than venous. In addition to the above, the following axioms may be stated as ascertained and determined in connexion with the mutual changes in the air and blood effected by respiration:—1, the arterial blood contains oxygen, and the venous blood carbonic acid; 2, the carbonic acid may be extracted from the blood by the contact of hydrogen or nitrogen; 3, as it is now ascertained that the vapour exhaled from the lungs does not result from a direct combination of the elements in those organs, but is to be regarded in the same light as the cutaneous transpiration, it appears reasonable to conclude that the excess of oxygen is absorbed and unites with the arterial blood, to which it imparts its scarlet colour. The conclusions to be drawn from the above propositions appear to be, that the great object of respiration is to rid the system of carbon; that this is effected by the combination of this element with oxygen; and that nitrogen is the vehicle by which oxygen is diluted and rendered respirable, at the same time that it partially aids in the extraction of the carbonic acid. These facts being admitted, it still remains a question where this chemical union of carbon and oxygen takes place. There appears no reason to doubt that oxygen permeates the air-cells, and is absorbed by the capillary pulmonary arteries at the same time that carbonic acid is given off by the capillary veins: thus a mutual interchange is constantly going on, which is probably referable to the laws by which the varying relation of gases is governed. It therefore seems most probable that

* This subject is treated of more at large in the section on the 'Nervous System,' p. 437.

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Anatomy. the carbonic acid is formed in the systemic capillaries; and this hypothesis receives support from the fact that the scarlet and purple colours of the arterial and venous systems is not confined to the blood in the large trunks, but extends to that in their minute ramifications; as well as from the further consideration that, as part at least of the animal heat, which is continually generated throughout the frame, is referable to the disengagement of caloric attending the union of the carbon with the oxygen, it is more probable such evolution would be diffused through the system generally, than that it should be concentrated in the lungs. It is, however, not improbable that this process may take place to a limited extent in the organs of respiration themselves. Dr. Stevens considered that the bright colour of arterial blood was attributable to the agency of the salts which the serum held in solution, rather than to the presence of oxygen.

*Physiology of the Larynx as an organ of Respiration and of Voice.*—The consideration of the larynx in its relation to the organs of respiration is limited to the mode of protection of the glottis, and the form and extent of the aperture called the rima glottidis. During ordinary inspiration and expiration the glottis remains open, and the larynx is equally passive with the rest of the air-tube; but when the admission of a large body of air rapidly into the lungs is required, the rima is widened by the action of the posterior crico-arytenoid muscles: when it is requisite that it should be closed, as in the acts of vomiting, coughing, or sneezing, this is effected by the contraction of the arytenoid and lateral crico-arytenoid muscles. In the act of deglutition the glottis is closed by the combined depression of the epiglottis and elevation of the larynx. In man and mammalia, the larynx is the primary organ for the production of sound; the further modulation which constitutes articulation is effected by the tongue, lips, teeth, &c. Thus, in the congenitally deaf, articulation is at best but very imperfect: the defect is not in the non-production of sound, but is the consequence of inability to imitate others, except by watching the motions of the lips. Observations and experiments prove that the rima glottidis is the spot where sound is produced, the vibration of the chordæ vocales being the cause. In treating of muscular agency in the production of the voice, it is necessary to bear in mind that the whole body of the larynx may be elevated and depressed; that the vocal chords and the connecting membranes are for the most part elastic; and that the arytenoid cartilages are highly moveable, their development being determined apparently by the extent of surface required for the action of muscles which influence the vocal chords. The muscles by which tension of the chordæ vocales is most directly accomplished are the crico-thyroid and sterno-thyroid; the crico-arytenoidei may also assist by retracting the arytenoid cartilages: on the contrary, the relaxors of the vocal ligaments are the thyro-arytenoid and thyro-hyoid muscles; the arytenoidei may likewise aid as antagonists to the crico-arytenoidei. It is erroneous to suppose that the different laryngeal nerves are distributed relatively and exclusively to antagonist muscles: the lateral and posterior crico-arytenoid, and the thyro-arytenoid muscles receive their supply from the superior laryngeal nerves, whilst the inferior supply the other muscles which move the larynx, in company with branches from the seventh and ninth nerves. Division of the laryngeal nerves is succeeded by loss of voice. The shape of the rima glottidis varies, according to the degree of separation of the vocal chords, from a mere chink to a triangular aperture: between these extremes there are numerous modifications, both in the extent of the opening and the form it assumes. The dimensions of the aperture of the rima does not, however, appear to exercise any important influence over the intonation of the voice, although it has been asserted that it is always narrowed during the emission of sound: this condition has been observed where the larynx has been laid open in attempted suicide. Experiments on the living structures are unsatisfactory and inconclusive; but those on the recent and separate larynx are much better calculated to throw light upon the subject: they are easily performed by fixing the cartilages and imitating the action of the various muscles; and as the vocal chords retain their elasticity for a considerable period, the effect is complete. The result of such experiments clearly proves that the degree of tension of the chordæ vocales is the effective cause of the modulation of that sound which is produced by their vibration; the width of the aperture having apparently no essential influence on the height of the tone, provided the chords are tense: but the notes are, *cæteris paribus*, lower in proportion to the length of the opening of the rima. The chordæ vocales are made tense, in part, by the approximation of the thyroid to the cricoid cartilage; thus, if the finger be placed on the larynx, it will be found that the former is fixed by being drawn up towards the os hyoides, and that the latter then approaches it in ascending the scale. The thyro-arytenoid muscles are important agents in the modulation of tones: they compress the chords, and therefore the rima glottidis, laterally; and must also greatly influence the vibrations of the former, in consequence of the close application of their fibres upon them. The higher tone of voice in females and boys depends upon the relative shortness of the vocal chords, and the obtuseness of the angle of their junction at the thyroid cartilage. The epiglottis has little to do with the voice; but it may, when pressed down, assist in deepening the tones. The whole length of the air-tube appears to be rather shortened than lengthened in producing the higher notes. The arches of the palate and uvula possess no influence; but the oral and nasal cavities and apertures are productive of resonance. According to Müller, the falsetto notes are produced by the vibration of the edges only of the vocal chords. Illustrations of the varied influence which different controlling agents possess in articulation may be readily found in the alphabet: thus, the vowels in the words *ah*, *name*, *theme*, *cold*, *cool*, exemplify, in their pronunciation, the modifying agency of the oral aperture: the explosive consonants, *b* and *p*, illustrate labial articulation: and again *d*, *t*, and *g* exhibit the combined operation of the tongue and palate: *f* and *v* are articulated by the united agency of the upper incisor teeth and lower lip: *s* and *z* are purely dental sounds; but *th* and *sh* require a proper relative adjustment of the tongue, palate, and teeth. Lisping depends on an inability to direct the current of air through the incisor teeth without a disturbing interference on the part of the tongue: the same defect results from the loss of teeth. A consideration of stammering in its varied forms is inconsistent with the limits of the present article.



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# A N A T O M Y.

## SECTION VIII.

### ORGANS OF ABSORPTION.



The organs concerned in Absorption consist of Glands or Ganglia, and vessels; the latter being further divided into the Lacteals, which convey the chyle from the intestines to the thoracic duct, and the Lymphatics, which hold a similar relation to all parts of the body.

*Lymphatic Ganglia.**—In the extremities these bodies are disposed almost exclusively in the concavity of the joints. In the lower limbs, the *Popliteal* ganglia are three or four in number, and are imbedded in the fat of the ham beneath the fascia. The *Inguinal* ganglia are placed in and near the groin, and consist of a superficial and deep set: the former are more numerous, being usually eight or ten in number, and lying upon and around the saphenic opening of the fascia lata, the deep set are two or three in number, placed beneath the fascia, and close to the femoral artery: one of these occupies the crural ring. The Ganglia of the upper extremity are the *Brachial*, which are scattered along the course of artery from the elbow upwards; and the axillary, which are large and numerous; they are imbedded in cellular tissue around the axillary vessels and nerves, extending upwards to the clavicles, and inwards as far as the costal attachment of the great pectoral muscle. The ganglia met with in the *Head* and *Neck* are (1) two or three small ones upon the parotid gland and beneath the zygoma; (2) upon the buccinator, and around the anterior belly of the digastric muscle; and (3) the superficial and deep cervical ganglia, the former of which lie immediately beneath the Platysma myoides, and the latter (glandulæ concatenatæ) are arranged beneath the fascia in the course of the carotid sheath, from the mastoid process downwards; internally they are in connexion with the pharynx. The *Pelvic* ganglia occupy the iliac, sacral, and hypogastric regions, being situated along the course of the iliac vessels, between the layers of the meso-rectum, and scattered amongst the divisions of the internal iliac artery, where they are related to the different pelvic viscera. The *Lumbar* ganglia are of larger size, and are found principally on either side of the vertebral column, and connected with the sacral ganglia below. The *Abdominal* ganglia are for the most part related to the great vessels in this region, such as the renal and divisions of the cœliac axis: the mesenteric are numerous, and important as associated with the lacteals; they lie between the laminæ of the mesentery, and are not found close to the intestine; but increase in size as they recede from it. Other ganglia are found between the layers of the meso-colon, and along both curvatures of the stomach. The principal *Thoracic* ganglia are found in the anterior mediastinum, and related to the great vessels near the heart; others are met with in the posterior mediastinum and intercostal spaces. The bronchial ganglia vary in number and size, although they are always numerous; they are situated before the bifurcation of the trachea, and surround the bronchi, accompanying them for some distance into the lungs: they are generally soft, and of a blackish colour, yielding a dark pigment, which some have supposed to be carbon separated during the act of respiration.

*Lymphatic vessels.*—The almost uniform relation of these vessels to the veins renders a minute and particular description of them unnecessary: they are arranged for the most part into superficial and deep sets, and communicate very freely, forming a net-work, particularly in the neighbourhood of large veins. The *superficial* lymphatics of the *leg* accompany the saphena veins, and the *deep* take the course of the tibial and peroneal vessels: some of the former from the back of the leg communicate with the latter in the popliteal ganglia, but the greater portion are collected on the inner and fore part of the thigh, and terminate in the superficial inguinal ganglia: the deep lymphatics continue their course upwards in company with the femoral vessels, and are similarly related to the deep inguinal ganglia. Here also terminate many other lymphatics from the surrounding parts; the superficial inguinal ganglia receiving those of the *hips*, *loins*, anterior walls of the *abdomen*, *perinæum*, *scrotum*, and *penis*. The deep lymphatics of the *penis* and those of the *bladder*, as well as those of the *uterus* and others, accompanying the branches of the *internal iliac* artery, terminate in the hypogastric ganglia. The lumbar ganglia receive the lymphatics of the *testicle* and *kidneys*, and others from the parietes of the pelvic cavity. The *iliac*, *sacral*, and *hypogastric plexus* unite and communicate with the *lumbar plexus* of lymphatics, which, becoming fewer and larger, ultimately empty themselves into the receptaculum chyli. The lymphatics of the *arm* are also *superficial* and *deep*: the former accompany the cutaneous veins, the latter the deep vessels, to the bend of the elbow, whence they ascend together to the axilla, where they terminate in the axillary ganglia; and subsequently, after communicating with the lymphatics of the head and neck, they terminate on the left side in the thoracic duct, and on the right they empty themselves by a short canal (small thoracic duct) close to the union of the right jugular and subclavian veins.

The axillary ganglia also receive the lymphatics from the walls of the *thorax*, the posterior part of the *neck*, and the *dorsal* region: the superficial lymphatics of the *head* join those of the *face*, which, together with those of the *orbits* and *nose*, and of the *tongue*, *palate*, and *pharynx*, ultimately terminate in the thoracic duct of their relative sides: some of these first pass through the parotid and submaxillary ganglia. The



* The title of 'Ganglia' is preferred to that of 'Gland,' as the bodies to which it is applied do not possess the ordinary properties or characters of secreting organs: indeed their function is very obscure.



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Anatomy. lymphatics of the *chest* consist of those which are met with in the interior of the walls, on the diaphragm, pericardium, and in the posterior mediastinum: those of the *heart* accompany the arteries of that organ. The *pulmonary* lymphatics are superficial and deep: the former form a net-work beneath the pleura, and the latter are distributed through the interior of the lungs: they terminate in the bronchial ganglia. All the above lymphatics ultimately empty themselves into the left or small right thoracic duct; occasionally some of them may be traced separately into the jugular or subclavian vein. In the *abdomen* the lymphatics of the *spleen* and *liver* are disposed in two planes, and are numerous and large in the latter organ, which they quit at different points, and ultimately pass by the anterior or posterior mediastinum to the thoracic duct, into which they empty themselves near to its termination. The lymphatics of the *stomach* are found on either surface of its muscular tunic, and accompany the arteries to the spine, where they join the thoracic duct. The *pancreatic* lymphatics have a similar termination. Lastly, the *lacteal* vessels (accompanied by other lymphatics) lie between the layers of the mesentery; and, after passing through the ganglia in this position, they become fewer in number and larger in size, and terminate in the thoracic duct. The *Thoracic duct* is the canal through which the chyle and greater part of the lymph is conducted to the venous system. It commences by the union of the large lymphatics from the lower part of the body, and the lacteals, upon the body of the second lumbar vertebra, at which point there exists a pouch-like dilatation, named *Receptaculum chyli*. It then ascends between the crura of the diaphragm, and through the posterior mediastinum, having the aorta on the right, and the vena azygos on the left, and being posterior to the œsophagus. Opposite the fifth or sixth dorsal vertebra, it crosses the spine obliquely to the left, and subsequently ascends behind the arch of the aorta to the interval between the parallel carotid and subclavian arteries of the left side, lying upon the longus colli muscle, and rising to a level with the seventh cervical vertebra. It then bends rather abruptly downwards and inwards, behind the inferior thyroid artery and left internal jugular vein, and terminates in the junction of the latter with the subclavian of the same side, the orifice being guarded by a pair of valves. In this course the Thoracic duct not infrequently divides several times, and again unites. It receives, at various points, the different lymphatics of the abdominal and thoracic parietes and viscera, as well as those from the left side of the upper half of the body. The corresponding branches from the right side empty themselves (as already described) by the *small Thoracic duct*, into the junction of the right subclavian and jugular veins.

*Structure and Functions of the Lymphatics.*—These minute vessels are most readily demonstrated in the mesentery of an animal shortly after being fed. In structure and distribution they are closely allied to the veins, but are more delicate in texture, and are less easily divisible into layers or coats. They are elastic, and capable of considerable distension; presenting also a most elaborate interlacement, from the infinity of anastomoses which exist between their branches, and possessing valves which occur in pairs at short intervals. Their inner or lining membrane is, like that in blood-vessels, smooth and polished, the outer being cellular and elastic. Lymphatic vessels are most numerous, as might be anticipated, in the most highly organized structures, with the apparent exception of the brain and nervous system, where they have not yet been traced, although they doubtless exist. The chief peculiarity of the absorbents is their association with the ganglia which have been described. These bodies are very vascular, but the nature of the influence they exercise over the lymphatics and their contents is not clearly ascertained.* The structure of the Lacteal vessels is identical with that of the lymphatics generally, their peculiar office being to convey the chyle from the intestines to the thoracic duct.† The exact relation of the ultimate branches of the lymphatic system to the textures in which they commence is not understood; and a careful examination of their exact relation to the ganglia through which they pass merely exhibits them subdividing minutely in these bodies, and again emerging as single trunks from them. It is probable that their absorbent power is principally referable to capillary attraction. However this may be, the "vis a tergo" has been known to be sufficient to burst the thoracic duct when compressed by a ligature; a fact which further illustrates the perfection and importance of the valvular arrangement. That the absorbents may be rendered more active under certain circumstances, appears to be proved by the judicious employment of mechanical or appropriate medicinal stimulus: it may, however, be questioned how far the phenomena alluded to may not be referred to a controlling influence exercised over the depositing vessels. Lymph nearly resembles the serum of the blood, but possesses corpuscles and a small quantity (about $\frac{1}{2}$ per cent.) of fibrin, whence it derives its property of coagulating. The different periods of life present remarkable variations in the relative activity of the absorbing and depositing vessels, as illustrated by the frame during childhood, at the adult period, and in old age: both processes are continually at work, by which a certain balance is maintained, and the interruption of which, to any extent, is either the result of unhealthy action, or itself constitutes disease.

* See 'Glandular Tissue,' p. 447.
† See 'Organs of Digestion,' p. 449.



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# ANATOMY

## SECTION IX.

### URINARY SYSTEM.



The organs by which the urine is secreted and conveyed to the bladder are contained in the abdomen: the last-mentioned membranous viscus occupies a part of the pelvic cavity. The *Pelvis* consists of three large bones, bound strongly together, and immoveable on each other; hence it forms a remarkable contrast to the distensible parietes of the thorax. It is divided into true and false pelvis: the former contains the organs of generation in the female, the rectum, and bladder; whilst the abdominal viscera rest on the iliac bones, above the ilio-pectineal lines. Of the upper strait of the pelvis the sacro-pubic diameter is the smallest, and the iliac or transverse the largest: on the contrary, the antero-posterior diameter of the inferior outlet exceeds that of the transverse, and is variable on account of the mobility of the coccyx. A line passing from the centre of the upper strait backwards, indicating its axis, would strike the lower third of the sacrum; that of the inferior, passing upwards, would strike the sacro-vertebral prominence, forming an obtuse angle where it meets the other line in the middle of the pelvic excavation. The female pelvis differs from the male in presenting a greater general capacity, its surfaces and prominences being smoother and less abrupt: the ilia are also more expanded or unfolded, and hence the hips are more prominent; the sacro-vertebral angle is not so marked, the sacrum is wider, and the angle of the pubic arch less acute; the sciatic tuberosities are set more outwards, and the acetabula are further apart. Lastly, as a consequence of the preceding peculiarities, the outlets of the female pelvis are larger than in the male.

The *Kidneys* occupy each lumbar region, lying on the quadratus lumborum and part of the diaphragm and psoas muscle, opposite to the last two dorsal and upper two lumbar vertebræ. Each is covered anteriorly by peritoneum; and the right has in front of it the duodenum and ascending colon, and the left is covered by the descending colon. Of the two kidneys the right is usually lower than the left, a peculiarity dependent on the position of the liver, with which it is in contact above. The upper extremity of the left kidney touches the spleen: the inferior margin of each touches severally the head and sigmoid flexure of the colon. The position of the kidneys is not exactly vertical, the superior or larger extremity approaching nearer to the spine. The external border of each is convex, and faces outwards and backwards; the internal edge is deeply notched where the vessels enter and the ureter makes its exit. The relative position of the arteries and veins here is not constant, but the former are usually behind the latter: the ureter is always posterior and inferior to both. Each kidney is invested by a dense fibrous capsule, which accompanies the vessels into its interior. A section of the kidney shows its interior to consist of a dark substance of a reddish brown colour, composed almost exclusively of the ramifications of the vessels. Internal to this, a paler structure (the tubular) is arranged in conical prominences (papillæ), the apices of which converge towards the centre of the organ, and are surrounded by membranous sacs called calyces. The papillæ present, on section, a linear arrangement of vessels (tubuli uriniferi), which open upon the surface of these cones. The membranous sacs are five or six in number, each containing one of two papillæ. The former unite into three tubes, named infundibula, which again join to form one large membranous bag, the pelvis. This contracts to form the ureter. The renal duct, or *Ureter*, extends from the pelvis of the kidney to the bladder, its ordinary length being about eighteen inches, and its diameter that of a common writing quill. The course of these ducts is obliquely downwards and inwards, crossing the psoæ muscles and the bifurcation of the common iliac artery: they adhere to the peritoneum which covers them, and are crossed by the spermatic vessels; also in the pelvis by the vas deferens in the male, and by the Fallopian tube in the female. The ureters contract in size as they approach their destination; and, behind the vesicula seminalis, each perforates the coats of the bladder very obliquely, to terminate about an inch and a half from its fellow, and the same distance from the orifice of the urethra. In the female the latter interval is somewhat less. The constituents of the ureter are, an external fibrous tunic, and one of mucous membrane within.

The *Supra-renal bodies* may here be noticed. They are attached to the upper extremity of each kidney, narrow above and broad below: their interior is excavated, and contains a brown fluid. Their use is unknown, though their large development in the fœtus would seem to indicate that their function is principally, probably exclusively, confined to uterine life.

The *Urinary Bladder* occupies the pelvis, but, when distended, ascends into the hypogastric region of the abdomen. It is of an oval form, its long axis being represented by a line passing from midway between the umbilicus and pubes to the extremity of the coccyx. Before the pelvis is fully developed, as in children, the bladder is more excluded from this cavity, and is pyriform in shape. Superiorly, the small intestines rest upon the bladder, and the urachus and hypogastric arteries are attached to it; inferiorly, it rests on the ureters, and in the male on the vesiculæ and prostate gland, but in the female on the vagina. Anteriorly, it is in contact with the recti muscles and posterior aspect of the pubes; posteriorly, the rectum is in contact with it in the male, but in the female the uterus intervenes. Lastly, the lateral regions are separated from the walls of the pelvis by the levatores ani





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and pelvic fascia. The bladder is partially covered by peritoneum, and this investment varies in extent according to the degree of distension of the bladder. When collapsed, a cul-de-sac is formed between the pubes and bladder, as well as between the bladder and rectum. The folds into which the peritoneum is thrown around the bladder are called its false ligaments. These are the posterior, which connect it to the rectum, and contain the ureter and obliterated hypogastric artery on either side; the lateral, which extend to the iliac fossæ, and contain the vasa deferentia in the male, and round ligaments in the female; and the superior fold, which connects the summit of the bladder to the recti muscles, and contains the urachus and hypogastric vessels. The true ligaments of the bladder are formed by the pelvic fascia, which is continuous with the iliac fascia of either side. In tracing this fascia, it is found to be separated into two laminæ by the interposition of the levator ani muscle; the external or obturator layer adhering to the obturator internus muscle, and closing the inferior outlet of the pelvis by its attachment to the tuberosities and rami of the ischium, the rami of the pubes, the triangular ligament of the urethra, and the great sciatic ligament. The vesical layer of the fascia is extended between the levator ani and peritoneum, and forms the true ligaments of the bladder: it is reflected from the walls of the pelvis laterally, upon the sides of this organ and the prostate gland; forming the lateral supports of the bladder, and extending forwards to the lower border of the symphysis pubis, whence it is reflected upon the upper surface of the prostate gland and neck of the bladder, where two folds are formed, named the anterior ligaments of the bladder. Posteriorly, this fascia becomes cellular in character, and is connected to the sides of the rectum, and surrounds the vessels and nerves. The bladder consists of an external serous coat, which has been already described as partial; and of an internal or mucous lining, which is continuous with that of the ureters and urethra. Between these is the muscular coat, which consists of strong red fibres, or rather bundles of fibres, which are spread in different directions over this hollow viscus, the superficial being principally longitudinal, and more distinct on the anterior and posterior aspects of the bladder than they are on its sides. The deeper fibres have an annular arrangement, and are most developed near the neck of the bladder. A layer of condensed cellular membrane connects the muscular to the mucous coat. The oblique perforation of the different tunics of the bladder by the ureters prevents the retrograde course of the urine when this viscus is distended; and it is expelled by the action of the detrusor muscle through the urethra.



*Structure of the Kidney.*—The most recent investigations into the minute anatomy and physiology of the kidney are those of Mr. Bowman.* The representations of the renal circulation in mammalia, which accompany the paper here alluded to, exhibit the extreme branches of the artery giving a terminal twig to each Malpighian tuft, from which emerges the efferent vessel: this enters the plexus of capillaries surrounding the uriniferous tube; and from this plexus the emulgent vein springs. The Malpighian bodies comprise but a small part of the inner surface of the kidney, there being but one to each tortuous tube. Mr. Bowman considers the peculiar arrangement of the vessels in the Malpighian tufts to be clearly designed to produce a retardation in the flow of the blood through them; and, he adds, "the insertion of the tuft into the extremity of the tube is a plain indication that this delay is subservient in a direct manner to some part of the secretive process." The peculiar arrangement alluded to, the same author thinks to be connected with the large proportion of aqueous particles contained in the urine. Mr. Bowman concludes by remarking the striking fact, "that the proximate principles of the urine, like those of the bile, are secreted *in all animals* from blood which has already passed through one system of capillaries—in a word, from portal blood; although it does not appear to what extent its qualities are changed by traversing the Malpighian system."† The secreted urine is ultimately poured out on the surface of the papillæ, where it is received by the calyces, and transmitted from them, through the infundibula, to the pelvis and ureter, and thence to the bladder. Recent urine, in the human subject, is of an amber or straw colour, varying in intensity according to its degree of dilution, or the presence of some of its constituents in excess: its reaction is decidedly acid, in health; but it becomes alkaline in some diseases, and by decomposition. The most essential constituent of the urine is urea, of which it contains about three per cent.; ninety-three parts being water, and the rest consisting of lactic and uric acids, and the salts of ammonia, soda, potash, lime and magnesia, with osmazome, extractive matter, and a trace of silica.‡

* The reader is referred to the original paper for particulars: it is in the *Philosophical Transactions*, part i., for 1842, p. 57.

† *Loc. cit.* p. 77.

‡ Berzelius, *Chimie Animale*, p. 342.

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# ANATOMY.

## SECTION X.

### OF THE ORGANS OF REPRODUCTION.



The *Male Organs* of Generation include the glands for the secretion of the fœcundating and other fluids, and the apparatus for conducting such secretion to its destination: the course of the semen will be followed in the ensuing description. The Testicles, which are two in number, are suspended in a bag called the *Scrotum*. This sac consists of skin which is continuous with that of the abdomen and thighs, but modified in texture, being very thin and lax, and presenting many sebaceous follicles and hairs scattered at intervals over its surface: it also presents a central ridge which is continuous with the raphé of the perinæum: the subcutaneous cellular tissue is devoid of fat. Beneath the skin is a texture peculiar to this part named the *dartos*; it is vascular and reddish in appearance, and is possessed of a contractile property: its connexions are to the rami of ischium and pubes laterally, and to the under part of the urethra in the mesial line, thus assisting in forming the partition between the testicles. The superficial fascia of the abdomen descends around each spermatic cord, and forms a distinct investment to either testicle. Beneath this are seen the expanded fibres of the cremaster muscle, which are spread over the fore part and sides of the testicle. The *tunica vaginalis* and *albuginea* are the more direct coverings of this gland: the former of these is a serous membrane, and originally a production from the peritoneum: it is loosely connected to the scrotum, but adheres firmly to the fibrous tunic of the testicle; the epididymis is the line of reflection, and its posterior margin is consequently left uncovered; it invests the cord to a limited extent. The dense fibrous coat of the testicle is named, from its appearance, *tunica albuginea*; and to it the peculiar form of this pulpy gland is due. Productions of this membrane extend into the interior of the testicle in the form of septa, to be presently noticed. In shape the *Testicle* is oval and somewhat flattened; its position in the scrotum is oblique, and the left usually hangs rather lower than the right. A section of the testicle exhibits its structure to be of a grey colour and pulpy consistence; it is made up of minute tortuous vessels, disposed in bundles, which are separated from each by the fibrous septa which project inwards from the tunica albuginea: these bands are continuous with the mediastinum testis, a broad process of the fibrous tunic which projects into the back of the gland, and consists of two laminæ enclosing the spermatic vessels and nerves: this process is broadest above where it is perforated by the excretory ducts. The tubuli seminiferi (as the minute spermatic ducts are called) unite to form larger vessels (tubuli recti), which vary in number from fifteen to twenty, or upwards: these take a parallel direction to the back part of the gland, where they are found between the layers of the mediastinum intermingled with the other vessels and nerves; they again unite into fewer and larger tubuli (vasa efferentia) which pierce the tunica albuginea, and ultimately form one single duct, the vas deferens. The *Epididymis* is an oblong body, narrow in the centre and bulbous at either extremity: its position is along the back part of the testicle, to which it is connected by the vasa efferentia above, and by the reflection of the tunica vaginalis through the rest of its course. Its upper extremity is named its head, and consists of the convoluted vasa efferentia; the globus minor, or tail, and intervening body are constituted of the coiled vas deferens, which at length becomes isolated, and assuming a denser character and larger size, it takes a serpentine course along the inner border of the epididymis, at the upper extremity of which it becomes connected with the other constituents of the chord, posterior to which it lies; and with them traverses the inguinal canal to enter the abdomen. At the internal ring the vas deferens leaves the other vessels, and, after hooking round the epigastric artery, descends backwards and inwards along the side of the bladder, crossing in its progress the psoas and iliacus muscles, the external iliac vessels, and obliterated hypogastric artery; it now approaches its fellow, at first lying anterior and then internal to the ureter, and next between the bladder and rectum; lastly, it passes to the inner side of the corresponding vesicula seminalis, the duct of which it joins as they together penetrate the prostate gland to enter the urethra.



The *Vesiculæ Seminales* are a pair of membranous canals with lateral appendages, convoluted in such a way as to assume an oval form: their position is between the inferior part of the bladder and the rectum, and above and behind the prostate gland, to which their anterior extremities are attached: the ureters are behind them, and the vasa deferentia are attached to their inner margins. The coils of the vesiculæ are so arranged as to present the appearance of an aggregation of cells: the duct of each joins that of the vas deferens. The *Prostate* is a conglobate gland, of firm and dense structure and grey colour, which surrounds the commencement of the urethra in the form of a truncated cone. It is covered superiorly by the posterior reflection of the triangular ligament, and inferiorly it rests upon the rectum; its sides are covered by the levator ani, and its base surrounds the neck of the bladder; whilst its apex extends to the membranous part of the urethra. The great bulk of the prostate is behind and on the sides of the urethra, and a superficial groove on either surface marks the junction of the lateral lobes, the central connexion between which



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has been named the middle lobe: the base of the gland is notched at the entrance of the common ejaculatory ducts. A dense capsule (the posterior layer of the deep perinæal fascia) envelopes the prostate, and is continued into that part of the vesical fascia which forms the anterior ligaments of the bladder and covers the upper surface of the gland. The prostatic ducts, to the number of ten or fifteen, open principally on the lower surface of the urethra, on the sides and surface of the Verumontanum. Anterior to the prostate, and lying between the layers of the deep perinæal fascia on either side of the membranous portion of the urethra, are two small *accessory glands*, first described by Cowper, and named after him: they are granular, and each about the size of a pea, possessing a small duct, about half an inch in length, which runs forward and opens into the spongy part of the urethra, immediately in front of the bulb.

The *Penis* is a cylindrical erectile organ which, in its relaxed condition, is pendent from the pubes, and rests upon the scrotum between the testicles. It is covered by the common integument, which is thin and connected to the body of the organ by lax cellular tissue wholly devoid of adipose matter: this skin extends beyond the extremity of the penis, forming the prepuce, and is then reflected on to the glans, where it becomes extremely delicate, and is ultimately continuous with the mucous membrane at the orifice of the urethra. A fold of the prepuce attached to the notch on the under part of the glans is named the frænum; it limits the uncovering of the penis, and probably may render the emission of the semen more forcible by acting on the urethral orifice during erection. At the junction of the prepuce and glans, and especially in the neighbourhood of the frænum, are a number of sebaceous follicles, named glandulæ Tysoni. A production of superficial fascia from the abdomen is continued around the penis, becoming more delicate as it advances, and terminating at the corona glandis. The body of the penis consists of the two corpora cavernosa, beneath which, and in the angular interval between them, the urethra is lodged: their extremities are surmounted by the glans penis, which is an expansion of the corpus spongiosum urethræ. The Corpora Cavernosa spring from two roots or crura, each of which is attached to the inner border of the corresponding ramus of the ischium, immediately in front of the tuba ischii, and adhering also to the ramus of the pubes: they are covered internally by the erectores penis muscles, and unite in front of the pubic arch. The anterior extremity of the conjoined cavernous bodies is conical and truncated: their junction above is marked by a groove, in which are lodged the two dorsal arteries and vein of the penis, whilst a deeper furrow beneath lodges the urethra. A flattened band of white fibres extends from the under and fore part of the symphysis pubis to the dorsal surface and posterior extremity of the cavernous bodies, under the name of suspensory ligament of the penis. The structure of the corpora cavernosa is essentially fibrous externally, and spongy or cellular within: a partition, consisting of flattened fibres, separates the two, and from its comb-like arrangement is named septum pectiniforme: this permits of a free interchange of vessels between the two sides of the organ. Their spongy texture consists of an intricate arrangement of fibrous and cellular bands, and the result is the production of a number of small cells, around and in which the vessels ramify.



The *Urethra* is the excretory duct common to the urinary and genital organs: it is from nine to twelve inches in length, extending from the bladder to the extremity of the glans penis, and lined throughout by mucous membrane, which is continuous with that of other parts of the genito-urinary system. The urethra is divided into different compartments, which vary slightly in calibre, and more importantly in other points, according to the structures by which it is surrounded: these divisions are severally named prostatic, membranous, bulbous, spongy, and glandular: its course is serpentine, and its interior presents the openings of the common ejaculatory, prostatic, and Cowper's ducts, in addition to those of many submucous follicles. The prostatic portion of the urethra somewhat exceeds an inch in extent: its direction is obliquely downwards and forwards, and it is nearer to the upper than the lower surface of the gland, the thick posterior wall of which alone separates it from the rectum: the interior of this division presents a central dilatation on either side of the median line, named the prostatic sinuses, between which and inferiorly is a prominent fold of the mucous membrane, named Verumontanum or caput Gallinaginis: in the middle of this fold a large lacuna opens, and on either side of it is the orifice of the common ejaculatory duct; the apertures of the prostatic ducts themselves form a crescentic range in either sinus. The membranous division is little more than half an inch long, and lies beneath the pubic arch, where it is supported by the deep perinæal fascia, which is reflected before and behind it, and by the conjoined anterior fibres of the levatores ani: its calibre is a little contracted, and its walls are thin: a plexus of veins from the dorsum of the penis is interposed between it and the pubes. The spongy portion of the urethra extends forwards from the last division to the extremity of the glans: it is so named from the texture which surrounds it, and constitutes about three-fourths of its whole length: the fibrous membrane which envelopes it is thinner than that of the corpora cavernosa, but its structure is essentially cellular and erectile, and similar in nature to that of the crura. The commencement of the corpus spongiosum is named the bulb, which is an expansion of this erectile tissue, occupying the angular interval between the crura penis near their junction: it projects backwards, and is invested by the anterior reflection of the deep perinæal fascia. The calibre of the urethra is here augmented in a marked manner, though not nearly in proportion to the circumference of the bulb itself. In front of the bulb the spongy portion of the urethra again contracts, and continues of uniform dimensions through the rest of its course until it approaches the glans: immediately in front of the sinus of the bulb are the openings of Cowper's ducts. The *glans penis* is a further expansion of the spongy texture above described, on the anterior and lateral parts of the urethra: it is invested by a delicate cuticle, and has a pink appearance: its size varies according to its degree of distension, and its form is that of a cone surmounting the corpora cavernosa, with its under part sliced obliquely: the apex of this cone presents the extremity of the urethra, which is an elongated aperture closed by lateral lips: the base of the cone is bounded by a prominent ridge which encircles the glans obliquely, and is named the corona glandis. The

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interior of the spongy division of the urethra exhibits the orifices of several lacunæ, the largest of which are on its upper surface, and all are directed forwards: these become more numerous towards the glans, near which one larger than the rest is named the lacuna magna. In the glans itself a remarkable transverse dilatation of the canal exists, which is called the fossa navicularis; whereas the orifice of the urethra is contracted so as to present the appearance of a vertical slit.

*Structure and functions of certain parts of the Male Organs of Generation.*—The texture of the *Dartos* has been a frequent subject of dispute amongst anatomists: that it possesses contractile properties there appears to be no question; and its action seems more allied to the vermicular or peristaltic motion of the involuntary muscles than any other. A recent author remarks that muscular fibres of the unstriped variety have been detected in its structure, to which the contractility of the dartos is due; and adds that the reason of their having been previously overlooked depends on their admixture with a great abundance of areolar tissue, which is nothing more than a modification of the same texture common to that region. The minute structure of the *Testis* presents several points for consideration. The convolutions of the tubuli seminiferi are so arranged that each lobule is a cone with its apex towards the rete testis: the last-named body consists of from six to twelve serpentine vessels, which receive the tubuli recti and anastomose with each other, being contained between the laminæ of the mediastinum or corpus Highmori. The vasa efferentia leave the rete, being at first straight and afterwards convoluted: they are (according to Louth) from ten to thirty in number, about eight inches long, and diminish in size as they approach the epididymis. The average length of the canal which forms the epididymis is about twenty feet. The diameter of all the tubuli is the same, being, according to Louth, $\frac{1}{178}$ of an English inch; and that of the vasa recta is $\frac{1}{88}$. The same author states that each lobule contains one, two, or (sometimes) several tubuli. He reckons the number of tubuli at 840, the length of one being about two feet: they anastomose freely only towards their extremities, nevertheless they rarely present free ends. From the above description it is apparent that the whole internal surface performs the office of secretion. A cæcal appendage of variable length, which probably secretes a peculiar fluid, usually joins the vas deferens where it leaves the epididymis; this is called 'vasculum aberrans.' The calibre of the *Vas deferens* is by no means proportioned to its diameter: its coats are thick and wiry to the feel, —a peculiarity affording the necessary resistance to pressure, which would interfere with the flow of the secretion. It has been thought by some that the *Vesiculæ seminales* were receptacles of the semen: their character and organization render it more probable that they furnish an additional secretion to lubricate the passages or dilute the fœcundating fluid. The *Prostate gland* is an example of the aggregation of several compound follicles into a single mass, or, in other words, a collection of smaller glands, each constituting a ramified tube with cellular extremities: its secretion is viscid and transparent. Professor Müller has given a particular account of the vascular arrangement in the *Corpora Cavernosa* penis: he describes the arteries as having two terminations, one of which is similar to that of other arteries, viz. for nutrition, and communicating with the minute radicles of the veins. The other set are derived from the sides of the arteries, and consist of short curled branches which are sometimes single, at others form tufts, and terminate abruptly, by apparently closed extremities. These, which he names *arteriæ helicinæ*, project into the venous cells, and are chiefly detected in the posterior part of the corpora cavernosa, and corpus spongiosum urethræ. The Professor conjectures that, though these helicine arteries present no openings, the blood is poured, during erection, from them into the venous cells, whence it would be subsequently and gradually absorbed by the veins. The proximate cause of this increased local action is an unexplained phenomenon, though probably referable to the same agency as that which accomplishes partial and temporary vascular activity in other parts and under other circumstances.* The opinions of Professor Müller have not received universal sanction; and others have failed to observe all that he describes. Whatever may be the correctness of the anatomical description just alluded to, the following facts seem to be apparent: that, for the production of *erection*, the blood must be retarded in the cells and veins of the penis, whilst it is still transmitted by the arteries. This may be effected in the following way by muscular action: the erectores penis command the corpora cavernosa, and by their action may therefore prevent the return of venous blood from them; at the same time that the acceleratores urinæ compress in like manner the spongy body of the urethra: this latter operation is further accelerated by the distension of the corpora cavernosa compressing the dorsal vein of the penis against the pubic arch. This explanation will transfer the seat of nervous operation from the vessels to the muscles; and it seems reasonable to suppose that, whatever may be the *primum mobile*, the phenomenon is mainly accomplished by that reflected nervous energy to which the remaining steps of the process, even to the consummation of the act of coitus by emission, are attributable. The persistent action of the erector muscles, and the spasmodic compression of the distended bulb by the ejaculators are acts wholly independent of volition.†

During the early part of fœtal life the Testicles lie within the abdomen, resting on the psoæ muscles, beneath the kidneys, and receiving, like these organs, a partial covering from the peritoneum. Each testicle is, at this period, attached to the pubic symphysis by a fibrous cord, named *Gubernaculum testis*, which extends through the inguinal canal and rings. This cord is broadest above, and presents a very small canal. By the gradual contraction of the gubernaculum the testicle is approximated to the internal ring, and about the beginning of the eighth month it commences its descent through the inguinal canal to the scrotum, carrying with it a reflection of the peritoneum, which is folded around it so as to form a partial, but double, investment to the organ. The communication between this production of the serous membrane and the general cavity of the peritoneum is subsequently cut off, and that portion which covers the greater part of the cord also degenerates into cellular tissue; so that the tunica vaginalis thus becomes a distinct and independent

* This subject has already been discussed under the head of the 'Vascular System.'

† For further particulars on this head, reference may be made to the 'Sense of Touch,' p. 431.

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Anatomy. serous sac, closely embracing the testicle and reflected along the line of the epididymis, as already described.

*Female Organs.*—The external organs of Generation in the female consist of the following parts. The *mons Veneris*, an adipose cushion in front of the pubes: this, in the adult, is covered with hair. The term "*vulva*" is applied to the external opening of the vagina. It is a fissure which extends backwards to within an inch of the anus, and which presents a superior commissure where the external labia are united above, and an inferior commissure, behind which and between it and the anus is the short perinæum. The external or proper *labia* are thick folds of integument which bound the vulva on either side; and within these are the *nymphæ* or smaller labia, which diverge as they descend from either side of the clitoris, and are gradually blended below with the common integuments of the vulva: they contain erectile tissue. The *clitoris* is within the vulva, and a little below its superior commissure: it is composed of elements analogous to those of the penis, possessing crura, which are attached to the rami of the pubes. These unite and are surmounted by a glans, around which a prepuce is folded; the structure of this body is cellular, like that of the spongy portion of the male urethra, and is capable of similar erection. The orifice of the *urethra* is situated about half an inch below the clitoris: this passage is very short in the female, being barely two inches in length. Its position is above the vagina, and it takes a curved course upwards and backwards beneath the symphysis pubis, to which it is connected by a production analogous to the triangular ligament in the male perinæum. The circular orifice of the external meatus is studded with mucous glands. The *Vagina* leads upwards from the vulva, and is attached internally around the neck of the uterus: it is surrounded externally by an annular muscle (analogous to the accelerator urinæ in the male), which extends from the clitoris around the vagina, and acts as a sphincter muscle. The clitoris possesses erector muscles similar to those of the male penis; and the other muscles of the perinæum and anus are alike in both sexes. The entrance to the vagina is originally partially closed by a reduplication of the mucous membrane (*hymen*), which leaves a circular aperture. After coition it ceases to exist, and in its place small red prominences are seen, named the myrtiform caruncles. In examining the form and course of the vagina, it is found to be about six or eight inches in length, and slightly curved, its concavity looking towards the bladder. Its lateral diameter exceeds its antero-posterior, and it is most capacious in the centre: its posterior wall is also much longer than its anterior, and is partially covered by the peritoneum, which descends to form a cul-de-sac between it and the rectum. The constituents of the vagina are an external fibrous tissue, which presents a plexiform arrangement of vessels, giving the part an erectile character, especially near the vulva; and a lining of mucous membrane, which is thick and dense, studded with mucous follicles, and presenting transverse folds or rugæ. The *Uterus* and its appendages constitute the internal organs of generation in the female. The position of the uterus is between the rectum and bladder: it is about two inches in length, and its breadth is rather less. Its superior extremity is expanded, and named its fundus, to which its narrow neck inferiorly is connected by the intervening body. The cervix uteri is embraced by the vagina, which extends higher on its posterior than on its anterior aspect. Anatomy. The body of the uterus is flattened, its antero-posterior diameter being little more than the thickness of its walls. That portion of the organ which projects into the vagina, presents the mouth of the womb (os tincæ), which is a transverse fissure bounded by smooth lips, of which the anterior is the thicker. The cavity of the uterus is very small: superiorly and laterally are the small orifices of the Fallopian tubes: it is lined by a layer of delicate mucous membrane which is continuous with that of the vagina, and sends a prolongation into either Fallopian tube. The serous investment of the uterus is derived from the peritoneum, in its progress from the back of the bladder to the rectum. On either side of the womb this reflection is intercepted by the Fallopian tubes, and thus forms a broad fold, expanding laterally, and dividing the cavity of the pelvis into two compartments. The ovaries and round ligaments are also contained between the layers of this reduplication, which is named the broad or suspensory ligament of the uterus. The round ligaments are attached to the upper or fore part of the uterus laterally, in front of and below the connexion of the tubes. They pass upwards, outwards and forwards to the internal rings; and after traversing the inguinal canals, terminate by expanding on the mons Veneris: they consist of condensed cellular tissue and several vessels. The *Fallopian tubes* are two canals, which lie in the superior folded border of the broad ligaments: they are four or five inches in length, and extend from the angles of the fundus outwards, expanding towards their extremities, and terminating by open fringed mouths, called their fimbriated extremities. The *Ovaries* are enclosed in the folds of the broad ligaments, occupying the interval between the round ligaments and Fallopian tubes, and placed very near to the open extremities of the latter, being, in fact, usually partially attached to one or more of the fimbriæ. The inner margin of each ovary is connected to the uterus by a ligament about an inch and a half long: the appearance of these organs is not unlike that of a small compressed testicle, and they are surrounded by a fibrous capsule similar to the tunica albuginea of that organ.

*Structure of the Uterus and Ovaries.*—The walls of the uterus are about half an inch thick, and its proper texture is close and resisting; its colour is grey; it is very vascular, and the arrangement of its fibres very complex. Although its properties, at the period of parturition, essentially identify it with muscular fibre, its actual muscularity has been always questioned from the absence of the usual characteristics of this tissue. Recent investigations, however, seem to leave no doubt of its belonging to the unstriped variety of muscular fibre—a peculiarity which has led to its being overlooked by earlier investigators. A section of the ovary exhibits several small vesicles, containing a viscid fluid. Some are delicate and pellucid; others are evidently more vascular, and contain a yellowish or brownish fluid. Some of these vessels encroach upon the surface, and others, having actually burst, leave a cicatrised spot behind.* Dr. Barry has recently com-

* For the physiological division of this section, the reader is referred to p. 126, of Vol. 8; and for a description of the Female Mamma, to p. 139 of the same Volume.



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municated the interesting fact of his having observed the spermatic animalcules on the ovary.

A close analogy may be traced between the apparently dissimilar external organs of generation in the male and female. The clitoris overhangs the orifice of the urethra, and has attached to either side of it the superior extremities of the nymphæ. If these last bodies were connected throughout their whole extent they would represent a continuation of the urethra, which would then terminate, as in the male, at the glans clitoridis. The most common forms of spurious hermaphroditism are associated with these analogies; viz., excessive development of the clitoris in the female, and hypospadic fissure of the urethra in the male.

True *Hermaphroditism*, which is the most frequent sexual arrangement in plants, is rare in the Animal Kingdom. Where it is found it exists in one or two forms, impregnation resulting from the concurrence of two or more individuals in which both sexes are developed, or in one individual independently. Many Mollusca and Radiata present illustrations of those forms of hermaphroditism which only exist as an abnormal development in the Articulate and Vertebrate classes. The different forms of spurious hermaphroditism, such as are met with occasionally in the human subject, are usually the result of arrested development. The distinction of sex does not take place in the human embryo until after the completion of the third month, when the margins of those small folds of integument which become the *nymphæ* in the female, are approximated to form the closed *urethra* of the male; the *labia majora* further corresponding to the folds which constitute the *scrotum* for the reception of the testicles. The concurrent existence of fissured urethra, with retention of the last-mentioned glands within the abdomen, and imperfect general development of the body, constitute the most common form of spurious hermaphroditism in the human subject, the true sex being, however, masculine. Abnormal development of the clitoris, and prolapse of the uterus in the female, have also given rise to doubts respecting the true sex. But the rarer instances, which present the nearest approximation to that perfect condition of double sexual development which is met with in the lower classes of animals alluded to, are those in which there exists an actual admixture of the genital organs of both sexes. Thus, a testicle on one side may co-exist with an ovary and Fallopian tube on the opposite: in these cases an ill-developed uterus is usually found, with an imperforate and small penis, and a fissure terminating in a cul-de-sac beneath it. In other instances, the external organs of the female are comparatively perfect, but the uterus is small or altogether wanting; and, in place of the ovaries, testicles are found, the ducts of which terminate in the uterus or vagina. The free-martin amongst cattle, to the anatomy of which Mr. Hunter directed attention in his *Animal Economy*, belongs to this variety of malformation. The case may be reversed, and the type of the external organs may be that of the male, with the exception of the testicles, whilst the internal organs as strictly belong to the female sex. A further variety involves a greater complexity, in exhibiting a tendency to the repetition of the corresponding organs of both sexes on the same side of the body: as in the co-existence of the uterus and vesiculæ seminales, or the testicles and ovaries. Lastly, cases are on record in which a more or less perfect uterus was superadded to the male genital organs. It is almost unnecessary to remark that, even in these nearer approaches to true hermaphroditism, the varieties alluded to are still widely removed from that normal condition which admits of self or mutual impregnation.

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# INDEX TO THE ANATOMY.





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SECTION X.

*Organs of Reproduction.*



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# MATERIA MEDICA.

MATERIA MEDICA is that department of the science of medicine which treats of the materials employed for the alleviation and cure of disease. The plan of the present treatise will not allow of our entering into all the botanical and chemical details usually contained in works on the subject of the Materia Medica; nor do these details possess sufficient interest, for the generality of readers, to render it at all desirable that much space should be allotted to them. Those who wish for further information on the botanical part of the subject we would refer to the Article BOTANY. In order to avoid much needless repetition, we shall preface our account of the various articles of the Materia Medica by a brief description of the most important pharmaceutical processes resorted to in the preparation of medicines.

The operations of pharmacy may be arranged in two classes; 1. Mechanical; 2. Chemical.

Under the first head are included the processes of weighing and measuring, and those for the mechanical division and separation of bodies. Those pharmaceutical processes which are purely chemical comprise various operations for the production of changes in the physical or chemical states of bodies, and in the performance of which we call to our aid the agency of water, and of other chemical agents.

## MECHANICAL OPERATIONS.

1. *The mode of determining the weight and bulk of bodies.*—The process of weighing is one so simple and so familiar to all as to render unnecessary any account of it in this place. In the compounding of medicines, the British Colleges direct the use of Troy weight. The subjoined Table exhibits the manner in which the pound is divided, and the signs employed for denoting the different weights.

| | | |
|---|---|---|
| A pound, ℔ | contains | Twelve ounces, ℥ xij. |
| An ounce, ℥ | | Eight drachms, ʒ viij. |
| A drachm, ʒ | | Three scruples, ℈ iij. |
| A scruple, ℈ | | Twenty grains, gr. xx. |
| A grain, gr. | | |

For the measure of liquids, the wine gallon is used, which, for medicinal purposes, is thus divided—

| | | |
|---|---|---|
| A gallon, C. | contains | Eight pints, O viij. |
| A pint, O. | | Twenty fluid ounces, f. ℥ xs. |
| A fluid ounce, f. ℥ | | Eight fluid drachms, f. ʒ viij. |
| A fluid drachm, f. ʒ | | Sixty minims, ♏ lx. |
| A minim, ♏ | | |

The specific gravity of liquids is frequently taken as a measure of their goodness and purity; alcohol, for example, is strong in proportion as its gravity is low; the strength of sulphuric acid, on the contrary, is greater in proportion to its increase of specific gravity. In expressing the specific gravity of solids and liquids, distilled water is taken as the standard. The specific gravity of liquids is generally ascertained by means of the hydrometer; it may also be readily determined by means of a bottle to which a stopper is accurately fitted, and which is made to contain exactly 1000 grains of distilled water: the bottle is counterpoised, filled with the liquid the specific gravity of which we wish to ascertain, and the weight in grains will be the specific gravity of the liquid:—For example, alcohol would be found to weigh 815 grains, sulphuric acid 1845 grains: the specific gravity of alcohol is thus expressed, ·815; that of sulphuric acid thus, 1·845, water being taken as unity. In ascertaining the specific gravity of a liquid, it must be brought by calculation to a temperature of 60°, if the thermometer be above or below that point at the time of performing the experiment.

*Mechanical division of bodies.*—The cohesion of bodies often presents an obstacle to chemical combination, as well as to their medicinal action in the stomach; and the following mechanical operations are instituted for the purpose of reducing bodies to a state of minute division.

*Trituration* is performed on a small scale by the rotatory motion of a pestle in a mortar of glass, agate, or Wedgwood ware. On a larger scale, the same operation is performed by means of rollers of stone or of metal, which are made to turn upon each other by machinery. *Levigation* is a similar process to that of trituration; but in the former case the rubbing is assisted by the addition of a liquid which has not the power of dissolving the solid under operation. *Granulation* is employed for the mechanical division of metals: it is effected by melting the substance, and stirring it briskly until it becomes cold, or by pouring the melted metal into water, and agitating until it is cool, or by shaking it in a wooden box, the inside of which has been covered with chalk.

*Mechanical separation of bodies* is frequently effected by one of the following processes:—sifting, elutriation, filtration, expression, and despumation. The operation of *sifting* is employed for the separation of the coarser from the finer parts of powders. To effect the same purpose, the process of *elutriation* is sometimes resorted to in the case of powders which are insoluble in water. The powdered substance is briskly stirred with a large quantity of water, so as to diffuse it equally through the liquid: the finer particles remain suspended, while the coarser fall to the bottom of the vessel. The liquid in which the fine particles are suspended is then poured off, and allowed to remain at rest until the whole of the powder has become deposited; the supernatant liquor is then removed, either by careful decantation, or by an inverted syphon.

*Filtration* is used for separating fluids from solids, and sometimes for separating one fluid from another with which it is mixed. Thus, suppose we have a mixture of oil of turpentine with water; if we wet the paper filter with water, then pour on the mixture, the whole of the water will pass through, leaving the oil on the filter.

*Expression* is employed for obtaining the juice of fresh vegetables, and the fixed vegetable oils. The substance is first bruised or coarsely ground, then



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enclosed in a hair-cloth bag, and subjected to violent pressure between the plates of a screw-press.

*Despumation* is employed to clarify liquids which are too viscid to pass through a filter. It is sometimes necessary merely to heat the liquid, which then throws up a scum, that is to be carefully removed; but more commonly it is necessary to use the white of egg; the albumen is coagulated by the heat, it entangles the impurities, and rising with them to the surface, is removed in the form of a scum.

### Chemical Operations.

Under the head of chemical operations are arranged all those processes which effect changes in bodies by the agency of heat, or by the action of water, and other chemical agents. Those operations which are performed by the agency of heat alone are—*liquefaction, fusion, evaporation, distillation, rectification,* and *sublimation.* The operations which are performed by means of water and other liquids are—*solution, lixiviation, maceration, digestion, infusion, decoction,* and *extraction.*

The changes produced by the chemical action of one set of bodies upon another are—*decomposition, precipitation,* and *fermentation.*

*Liquefaction* is that process by which some bodies, when exposed to a moderate heat, are rendered fluid after passing through several intermediate states of softness. This process is adopted for the purpose of rendering fluid such bodies as fat, lard, wax, and resin, and thereby to facilitate their combination in the formation of ointments.

*Fusion* is a modification of liquefaction, but differs from it in the sudden changes from the solid to the liquid state, which those bodies which are liable to it suffer on exposure to heat. There are no intermediate states of softness; but the fusible body, when heated to a certain point, immediately assumes the liquid form. Fusion is generally confined to the metals, which are extracted from their ores, and afterwards smelted and alloyed by it.

*Evaporation* is the dissipation of a liquid, in the form of vapour, by means of heat; it is employed in pharmacy when we wish to obtain in the solid form any fixed substance which may be in a state of solution in water, or in any other vaporizable liquid. By this means we obtain a salt from its solution in water. When the process of evaporation is employed, the liquid is entirely dissipated and lost; hence, when the value of a liquid renders its preservation desirable, we have recourse to the process of distillation.

*Distillation* differs from evaporation in this, that the vapour of the liquid is again condensed and collected in another vessel; the vapour of the liquid in the retort carries off a large amount of latent heat, which is given up to the liquid surrounding the receiver, when the vapour again assumes the liquid form. The common still consists of a boiler which contains the liquid to be acted on; the boiler is surmounted by the head, which is drawn out into a tapering pipe, bent in an arched form, and terminating in the *worm.* The worm is a long pewter pipe, of a decreasing diameter, which winds in a spiral direction obliquely through a deep tub filled with cold water. The vapour arising from the liquid in the boiler is condensed in the worm, and issues in drops from the lower end of the pipe.

*Rectification* is the repeated distillation of any product obtained by distillation, for the purpose of obtaining it in a state of purity. The second operation is carried on at a lower temperature, so that the more volatile materials only are raised and pass over into the receiver, while the impurities remain in the retort. In the rectification of alcohol and ether, it is usual to put into the retort some substance, such as chloride of calcium, or carbonate of potash, which, by its affinity for the water, restrains it, and prevents its evaporation.

*Sublimation* is a species of distillation in which the substance acted on is a solid: the vapour arising from the volatilization of the solid is condensed, and reassumes the solid form. This process is employed in the preparation of calomel.

*Solution* is that process by which the cohesion of a solid is overcome by the attraction of a liquid solvent; in this action, the two forces of homogeneous cohesion and heterogeneous adhesion are opposed to each other; and when the two forces are exactly in equilibrio, the liquid is said to be saturated. Heat increases the solvent power of liquids by opposing cohesion, and at the same time increasing the force of attraction. When a liquid is saturated with one solid, it still retains the power of dissolving a second, and even a third, when saturated with the second; and so on until it holds in solution three, four, or more bodies at the same time.

*Lixiviation* is a term applied to solution when the substance acted on contains both soluble and insoluble matters. Thus, wood-ashes are lixiviated for the purpose of separating the soluble salts of potash which they contain: on a large scale, it is performed in a tub having a hole near the bottom. A layer of straw is placed near the bottom of the tub, over which the substance is spread and covered by a cloth; after which, cold or hot water, according as the salt is more or less soluble, is poured on. The water takes up the soluble parts, and, gradually filtering through the straw, escapes from the hole at the bottom of the tub.

*Maceration* is that operation by which the soluble parts of substances, chiefly of a vegetable nature, are obtained in solution by immersing them in *cold* water, or in spirituous fluids.

*Digestion* is an operation similar to maceration, except that the solvent power of the liquid is aided by a gentle heat.

*Infusion* is intended for the extraction of the volatile and aromatic principles of vegetables, which would be dissipated by decoction; and also those parts of vegetables which are more readily soluble in water, as gum, sugar, extract, tannin, and the salts. The water is poured boiling hot on the materials sliced or reduced to a coarse powder, and kept in a closely-covered vessel until they are cold, when the infusion is decanted off for use.

*Decoction*, or boiling, is intended to answer the same purposes as infusion; but in this operation the solvent power of the liquid is increased by the long-continued application of the boiling temperature. Decoction is employed with advantage to extract the mucilaginous parts of plants, their bitterness, and several other of the vegetable principles.

*Extraction.*—If an infusion or a decoction be subjected to evaporation, the liquid part is evaporated, and the substances dissolved in it are obtained in a solid form, and receive the name of an extract.

*Decomposition* implies the separation of the component parts of bodies from one another. It may be

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produced by heat, or by electricity, but in most cases it is the result of the superior affinity of some chemical agent for one or more of the elements of a compound. When nitric acid is added to carbonate of ammonia, the carbonic acid is displaced by the greater affinity of the stronger acid for the ammonia; nitrate of ammonia is formed, and the carbonic acid escapes with effervescence. This is a case of decomposition by *single elective* affinity. If, instead of adding nitric acid to carbonate of ammonia, we mix a solution of nitrate of lime with one of carbonate of ammonia, we have a case of *double elective affinity*, and *double decomposition* occurs. The carbonic acid leaves the ammonia, and, combining with the lime, forms carbonate of lime, which, being insoluble, falls to the bottom of the vessel; at the same time the nitric acid being transferred from the lime to the ammonia forms nitrate of ammonia, which remains in solution. Many pharmaceutical compounds are prepared by the process of decomposition: and the prescriber must be careful not to associate such substances as decompose each other. For example, if to the compound infusion of roses we add acetate of lead, the sulphuric acid in the infusion combines with the lead, an insoluble sulphate of lead is formed, and the patient, who it might be supposed was taking sulphuric acid and lead, would, in fact, be taking neither the one nor the other.

*Precipitation* is an operation in which decomposition occurs, a solid substance being thrown down from a liquid in which it was held in solution, by the chemical action of another body which is added to the solution. The substance employed to produce the precipitation is called the *precipitant*, the substance which is separated by its action, the *precipitate*. Thus, if into a solution of sulphate of magnesia a solution of soda be dropped, the magnesia separates from the sulphuric acid, falls to the bottom, and forms the precipitate; while the alkali, which is the precipitant, combining with the acid thus set free, remains in solution in the state of sulphate of soda.

*Fermentation.* — The constituents of vegetable matter, when separated from the living plant, and placed under certain circumstances, act upon one another, a spontaneous decomposition and metamorphosis occur, and new compounds result. This process has been denominated *Fermentation;* and as its phenomena and results vary according to the nature of the vegetable matter subjected to it, and the circumstances under which it occurs, the general process is divided into different species, easily distinguished from each other. *Diastase* is a remarkable principle, which is produced in the incipient germination of grains and seeds, and the tubers of potatoes; this substance has the power of converting starch into sugar, and the process by which the change is effected is termed the *Saccharine* fermentation. If to a saccharine liquid we add a small quantity of animal albumen, fibrine, or gluten, in a state of putrefaction or spontaneous decomposition, keeping the mixture at a temperature of about 70°, we determine in it the process of what is called the *Vinous fermentation;* carbonic acid gas escapes, and the sugar becomes converted into alcohol. A liquid which has undergone the vinous fermentation, if exposed to the air, is capable of another metamorphosis; the alcohol abstracts oxygen from the air, and becomes converted into acetic acid and water: this is designated the *Acetous fermentation.* Most vegetable substances, when subjected to the influence of air, moisture, and a moderate temperature, undergo the *Putrefactive fermentation;* their elements enter into new combinations, gases having a fœtid odour escape, leaving behind only a small quantity of earthy and metallic matter.

We next proceed to give an account of the various articles of the Materia Medica, and of the most important substances prepared from them. For convenience of reference, we shall arrange them in alphabetical order:—

Abietis resina.—Vide *Pinus abies.*

Absinthium.—Vide *Artemisia Absinthium.*

Acacia.—*Sex. syst. Polygamia. Monœcia. Nat. ord. Leguminosæ.*

### 1. Acacia Catechu.

The Acacia Catechu, from which the catechu of commerce is obtained, grows in various parts of the East Indies, and is now common in Jamaica. Catechu is obtained by boiling the wood in water; the decoction is then evaporated until the extract is of sufficient consistence to be poured into clay moulds.

*Qualities.*—There are two varieties of catechu in commerce, the pale and the dark. Pale catechu is generally in small cakes, of a pale reddish-brown colour, light and friable, with a lamellated texture and rough fracture; has a bitterish and astringent taste, leaving a degree of sweetness on the palate; is inodorous, and has a specific gravity between 1·28 and 1·39. The dark variety, which is in round masses, has a deep chocolate colour internally, with the hue of rusty iron on the outside; the texture is uniform, and the fracture resinous, marbled, and shining. It is heavier than the pale, the specific gravity being 1·45, and has a more austere and bitter taste; but in other respects it agrees with the other kind.

Composition.—The following is the analysis of a specimen of each variety, by Sir H. Davy:—

| | Dark. | Pale. |
|---|---|---|
| Tannin | 54·5 | 48·5 |
| Peculiar extractive | 34·0 | 36·5 |
| Mucilage | 6·5 | 8·0 |
| Insoluble matter (chiefly sand and lime) | 5·0 | 7·0 |
| Catechu | 100·0 | 100·0 |

Physiological Effects.—Catechu produces the local and general effects of a vegetable astringent.

Uses.—Employed as an astringent in the following cases:—In cases of chronic inflammation of the throat, usually called relaxed sore throat: it may be chewed or sucked. It is occasionally used in the same way by public speakers or singers to prevent hoarseness. As an astringent in diarrhœa, it may be usefully combined with chalk or opium. As an astringent in atonic hæmorrhages, and in cases of gleet and fluor albus. It is also occasionally used as a topical application to flabby ulcers.

Administration.—Dose, grs. x. to ℈ i. It may be given in the form of a bolus, or in the form of infusion or tincture.

Acacia Vera.—This species of Acacia is found in almost every part of Africa, but the tree that yields the gum which is exported from Barbary to Great Britain grows principally in the Atlas mountains. The gum of the Acacia tree flows, in the liquid state, from the trunk and branches, and hardens by exposure to the air. It

usually exudes spontaneously; in some instances, however, the discharge is facilitated by incisions. USES.—Gum is employed in medicine for its nutritive, emollient, and demulcent properties; it is very commonly used as a vehicle for more active medicines. It is sometimes slowly dissolved in the mouth to allay troublesome cough, and to diminish irritation of the fauces. It is used as a demulcent in inflammatory affections of the intestines, as well as of the urinary and respiratory organs. As a vehicle for the exhibition of other medicines, it may be taken *ad libitum* in the form of powder or mucilage.

ACETOSELLA.—Vide *Oxalis Acetosella.*

ACETUM—*Vinegar*—prepared by exciting the acetous fermentation in substances which have undergone or are susceptible of the vinous fermentation. In this country it is prepared from malt, which is mashed with hot water, as in the ordinary operation for brewing. The cooled wort is then transferred to the fermenting tun, where it is mixed with yeast, and undergoes the vinous fermentation. The wash is then introduced into barrels, and a moderate heat is kept up until the acetous fermentation is complete. This process occupies several weeks, or even months. The liquor thus procured is then introduced into large tuns furnished with false bottoms, in which is placed *rape*, the residuary fruit which has served for making domestic wines. These rape-tuns are worked by pairs; one of them is quite filled with vinegar from the barrels, and the other only three-quarters full, so that fermentation is excited more readily in the latter than in the former, and every day a portion of the vinegar is conveyed from one to the other till the whole is completely finished and fit for sale. For a brief explanation of the acetous fermentation, vide p. 497. Vinegar consists of *water*, *acetic acid*, *colouring matter*, a *peculiar organic matter* commonly called mucilage, a small portion of *alcohol*, and a *peculiar odorous principle*. Vinegar makers are allowed to add one-thousandth part by weight of sulphuric acid. ADULTERATION.—It sometimes contains an excess of sulphuric acid; hence it is ordered that the sulphate of baryta precipitated when chloride of barium is added to a fluid ounce of vinegar shall not exceed 1·14 grains. EFFECTS.—Vinegar acts as a tonic, refrigerant, diaphoretic, and diuretic; and externally applied it is moderately stimulant and astringent. USES.—It is sometimes used in fevers to acidulate the ordinary beverage, but it is seldom employed alone. Dose, f. ʒ ſs. to f. ʒ iv.

ACETUM DISTILLATUM — *Distilled Vinegar*—prepared by distilling vinegar in a sand-bath from a glass retort into a glass receiver. The seven pints first distilled are kept for use. By distillation the vinegar is freed from its colouring matter and sulphuric acid. It is a mixture of acetic acid, a little alcohol, and water. Thirteen grains of the crystals of carbonate of soda are saturated by 100 grains of distilled vinegar. ADULTERATION.—Sulphuric acid may be detected in it by a precipitate being produced on the addition of chloride of barium. USE.—Chiefly in pharmacy.

ACIDUM ACETICUM—*Acetic Acid*—prepared by adding dilute sulphuric acid to acetate of soda, and distilling from a sand-bath. PROPERTIES.—It is limpid and colourless, its smell is pungent, and its taste acrid. 100 grains saturate 87 grains of crystallized carbonate of soda. A mixture of 15 parts by weight of this acid, and 85 of water, is equal in strength to distilled vinegar.

PURITY.—Sulphuric acid may be detected by adding chloride of barium, and metals by the change of colour produced by passing a current of sulphuretted hydrogen through the liquid. EFFECTS.—In the concentrated state, it is an irritant and corrosive poison. Applied to the skin, it acts as a rubefacient and vesicant. In moderate doses it is refrigerant, tonic, diaphoretic, and diuretic. USES.—In small doses, taken as a refrigerant drink in fevers and inflammatory diseases. It is sometimes used as a gargle, and as an external application to ulcers. It is much used in pharmacy. ANTIDOTES.—In cases of poisoning by this, or by any of the strong acids, the antidotes are chalk, whiting, or magnesia suspended in water. In the absence of these, soap-suds, infusion of wood ashes, weak solutions of carbonate of potash or soda, white of eggs, gelatine, milk, oil, or in fact any mild diluent, should be immediately administered.

ACIDUM ARSENIOSUM.—Vide *Arsenicum.*

ACIDUM BENZOICUM—*Benzoic Acid*—obtained from gum benzoin by sublimation. EFFECTS.—Internally, it acts as a stimulating expectorant. When benzoic acid has been taken internally, hippuric acid is found to exist abundantly in the urine. Dr. Ure affirmed that the hippuric acid was formed by the action of benzoic acid on the uric acid in the urine, and he has recommended the use of benzoic acid to dissolve uric acid calculi, *i. e.*, by converting the insoluble uric acid into the soluble hippuric. Liebig, however, states that the hippuric acid is formed from the benzoic acid alone, and that the quantity of urea and uric acid is not lessened by taking benzoic acid.

ACIDUM CITRICUM—*Citric Acid*—obtained from the juice of lemons. Chalk is added to the heated lemon-juice: we thus obtain a citrate of lime, which is then boiled with dilute sulphuric acid; an insoluble sulphate of lime is formed, and the citric acid is poured off with the water, and obtained by evaporation. The crystals are in the form of right rhombic prisms, white and semi-transparent. The taste is extremely acid. EFFECTS.—Small quantities of citric acid dissolved in water allay thirst, diminish preternatural heat, check profuse sweating, and promote the secretion of urine. USES.—Often employed in the preparation of refrigerant drinks, and still more frequently combined with bicarbonate of potash in the formation of the effervescing draught. 14 grains of citric acid will saturate ℈j. of bicarbonate of potash. Citric acid is frequently used as an anti-scorbutic.

ACIDUM HYDROCHLORICUM—*Hydrochloric or Muriatic Acid*—prepared by adding dilute sulphuric acid to chloride of sodium, and distilling. In this process sulphate of soda is formed, and remains in the retort; the hydrochloric acid distils over, and is condensed with the water in the receiver. Hydrochloric acid gas is composed of one atom of hydrogen and one of chlorine. The acid of the pharmacopœia is an aqueous solution of the gas. It is a limpid colourless liquid, having a specific gravity 1·16. EFFECTS.—In small doses this acid produces the usual effects of a mineral acid; it is tonic, refrigerant, and diuretic, and usually relaxes the bowels. In large doses it acts as an irritant poison. USES.—As a tonic, combined with vegetable bitters, in some malignant fevers. To remove phosphatic deposits from the urine. In some cases of dyspepsia, especially when the urine is alkaline. It has also been used as a tonic in venereal and scrofulous diseases. Externally it may be used as a caustic, or when diluted as a gargle in cases

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of ulceration of the mouth and throat. Dose, from five to fifteen minims, properly diluted. The dilute hydrochloric acid is composed of four fluid ounces of the strong acid, and twelve fluid ounces of water; it may be given in doses of from half a fluid drachm to one fluid drachm. Antidotes.—The same as for the Acetic Acid.

Acidum Hydrocyanicum—*Hydrocyanic or Prussic Acid.*—This acid is readily procured from many vegetables, as from bitter almonds, apple-pips, the kernels of peaches, apricots, cherries, plums, and damsons; the flowers of the peach, cherry-laurel, and bird-cherry; the bark of the latter, and the root of the mountain ash. Preparation.—The processes for procuring this acid are numerous, and most of them complicated. We may mention one process directed by the London Pharmacopœia for the extemporaneous preparation of the dilute acid. "Add 48½ grains of cyanide of silver to a fluid ounce of distilled water, mixed with 39½ grains of hydrochloric acid. Shake all these in a well-stoppered phial, and, after a short interval, pour off the clear liquor into another vessel. Keep this for use, the access of light being prevented." In this process an insoluble chloride of silver is formed, and hydrocyanic acid mixed with water is poured off. Qualities.—A colourless transparent liquid, having an odour like that of bitter almonds; its taste is bitter and peculiar. By exposure to air and light, the acid soon undergoes spontaneous decomposition. The acid is directed in the Pharmacopœia to be prepared of such a strength that 100 grains of it will exactly precipitate 12·7 grains of nitrate of silver dissolved in water: the precipitate, which is cyanide of silver, should weigh 10 grains. Hence the dilute acid should consist of real hydrocyanic acid 2·0, water 98·0. Effects.—In small doses this acid relieves certain morbid conditions without producing any evident change in the condition of the general system. If the dose be gradually increased, it gives rise to a bitter hot peculiar taste; increased secretion of saliva; frequently nausea; disordered and laborious respiration; pain in the head, giddiness, obscured vision and sleepiness. In poisonous doses, it produces a sudden sensation of giddiness and faintness, succeeded by tetanic convulsions and insensibility; the respiration is difficult, and the odour of the acid is recognized in the breath; the patient may recover rapidly from this state, or it may terminate in death. When a very large dose is taken, the pulse immediately becomes imperceptible, the breathing not obvious, or there may be two or three deep hurried inspirations, insensibility, and death. Convulsions may or may not be present. There are no morbid appearances observed in cases of poisoning by this acid which at all explain its *modus operandi*. It evidently acts powerfully on the nervous system; and so rapid are its remote effects, that it is difficult to account for them by the slow process of absorption; hence many persons have felt constrained to admit that it acts on the nervous centres by an impression produced on the extremities of the nerves with which it is brought into contact. Uses.—This acid is remarkably efficacious in curing some painful affections of the stomach and intestines, which have received the name of *gastrodynia* or *enterodynia*. It is sometimes useful in allaying vomiting and purging. Formerly it was much used in affections of the pulmonary organs, especially in phthisis, hooping-cough, and asthma; at present it is but little employed in such cases, but is occasionally useful in relieving spasmodic cough. It has been used in cases of hysteria, epilepsy, chorea, and tetanus, but without any decided benefit. It is said to have mitigated the symptoms of hydrophobia. Externally.—This acid has been added to lotions for the treatment of irritating cutaneous diseases; when thus used there is some danger of absorption, and the consequent production of constitutional symptoms. Dose, from three to five minims of the dilute acid in any simple vehicle, repeated three or four times a day. Antidotes.—Chlorine water, or solutions of chloride of lime or chloride of soda. Chlorine acts by decomposing the hydrocyanic acid, forming hydrochloric acid, and setting free cyanogen. Ammonia should be given as a stimulant. Cold effusion to the face and chest. Artificial respiration ought never to be omitted, as in most cases the immediate cause of death is obstruction of the respiration.



Acidum Nitricum—*Nitric Acid*—prepared by adding sulphuric acid to nitrate of potash, and distilling. Sulphate of potash remains in the retort, and nitric acid passes over, and is condensed with a minute quantity of water. Properties.—Liquid nitric acid is a colourless or very pale yellow limpid fluid, emitting, when exposed to the air, white suffocating vapours. It is highly corrosive, and tinges the skin yellow, the tint remaining till the epidermis peels off. About 217 grains of the crystals of carbonate of soda are saturated by 100 grains of this acid. Its specific gravity is 1·50. When poured on volatile oils, this acid imparts oxygen to them so rapidly as to set them on fire, and it is capable of oxidizing all the metals.

Acidum Nitricum Dilutum is composed of one fluid ounce of strong acid, and nine fluid ounces of water. Physiological Effects and Uses.—The strong nitric acid applied to the skin acts as a powerful escharotic, and for this purpose is sometimes applied to sloughing and phagedænic ulcers. It is sometimes applied to poisoned wounds, with the object of decomposing the poison. The dilute acid is frequently used as a tonic, and is especially useful in many cases of debility, accompanied with an alkaline state of the urine. It is often given with advantage in cases of secondary syphilis, when mercury is contra-indicated; in scrofulous subjects, for example. Dose.—The dilute acid may be given in doses of from ℥ x. to ℥ xxx., three or four times a day. Antidotes.—The same as for Acetic Acid.

Acidum Oxalicum—*Oxalic Acid.*—This acid exists ready formed in many vegetables. In the leaves of the wood-sorrel it is found combined with potassa. That which is found in the shops is produced artificially, by boiling sugar with nitric acid. The nitric acid gives oxygen to the sugar, converting the hydrogen into water, and the carbon into oxalic acid. The composition of oxalic acid is—carbon two equivalents, oxygen three equivalents. Properties.—The crystals of oxalic acid are flat four-sided prisms. They are white, transparent, have a very acrid sour taste, and redden all the vegetable blues, except indigo. Oxalic acid is distinguished by effecting a white precipitate with lime-water, which is insoluble in an excess of the acid. With a solution of nitrate of silver it gives a white precipitate of oxalate of silver; this precipitated, dried, and heated over a spirit lamp, is dispersed with a feeble detonation. We have been more minute in describing the properties of oxalic acid, in consequence of the serious error, which has frequently been committed, of taking it for sulphate

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of magnesia. The acid taste of the former, and the bitter taste of the latter, would sufficiently distinguish them if persons would taste their medicines before swallowing them. PHYSIOLOGICAL EFFECTS AND USES.—Oxalic acid, in small doses, and in a large quantity of water, sweetened with sugar, forms an agreeable cooling beverage in febrile diseases. In large doses it acts as a virulent and rapidly fatal poison. It produces vomiting, frequently of bloody matter, from its action on the stomach, and, soon becoming absorbed, it acts on the nervous system, producing faintness, convulsions, and death. ANTIDOTE.—The best antidote for oxalic acid is chalk, which should be given powdered and suspended in water; an insoluble and inert oxalate of lime is formed, which may then be removed by the exhibition of emetics.

ACIDUM PHOSPHORICUM DILUTUM—*Dilute Phosphoric Acid*—prepared by the action of dilute nitric acid on phosphorus. PROPERTIES.—A colourless inodorous liquid, having an acid taste. EFFECTS AND USES.—It possesses tonic properties, and may be given in all cases in which the mineral acids are indicated; it may be given for a longer time without disordering the stomach. DOSE, from ♏ x. to ♏ xx.

ACIDUM SULPHURICUM—*Sulphuric Acid.*—The process for procuring this acid is too complex to admit of explanation within the prescribed limits of this treatise; we would refer those of our readers who seek for full and accurate information on this or any other subject connected with the Materia Medica, to the admirable and elaborate treatise of Dr. Pereira, on the *Elements of Materia Medica.* PROPERTIES.—Sulphuric acid is a colourless transparent heavy liquid, having the consistence of oil. It has a specific gravity, 1·845. It is highly corrosive, has a great affinity for water, abstracting it from any animal or vegetable tissues with which it comes in contact, and thus producing a charring effect. EFFECTS AND USES.—This acid is a valuable tonic and astringent. It is usually combined with some vegetable tonic, and is most useful in checking profuse perspirations occurring in debilitated and hectic states of the system. In large doses it is a powerful corrosive poison, giving rise to excruciating pain in the stomach and bowels, faintings, feeble pulse, cold sweats, vomiting, difficult deglutition, convulsions, and death. The symptoms in cases of poisoning by all the mineral acids differ in no important particular, and there is this remarkable point, that the vomited matters produce effervescence when brought into contact with chalk or marble.

ACIDUM SULPHURICUM DILUTUM—*Dilute Sulphuric Acid*—is prepared by adding to fourteen ounces and a half of distilled water one ounce and a half of the strong acid. Dose from ♏ x. to ♏ xxx. ANTIDOTES.—The same as for Acetic Acid.

ACIDUM TARTARICUM—*Tartaric Acid*—obtained from the bitartrate of potassa. This salt is boiled with lime and chloride of calcium; an insoluble tartrate of lime is formed, which is then treated in the same manner as the citrate of lime in preparing citric acid. PROPERTIES.—Tartaric acid in its crystalline state is white, imperfectly transparent, very acid, readily soluble in water: at a high temperature it is decomposed into carbonic acid and water. EFFECTS AND USES.—The same as those of Citric Acid.

ACONITUM NAPELLUS—*Monk's Hood.*—*Sex. syst. Polyandria. Trigynia. Nat. ord. Ranunculaceæ.* HAB.—Europe, a doubtful native. PARTS USED, the root and leaves. DESCRIPTION.—Aconite root, when fresh, consists of a tapering root-stock, and of numerous cylindrical fibres arising from it; its colour is externally coffee brown, internally white and fleshy; its taste is bitter, but after a few minutes a remarkable numbness and tingling is perceived on the lips, tongue, and fauces. By drying, the root shrivels and becomes darker coloured; the *leaves*, when chewed, have the same taste, and produce the same feeling of numbness. COMPOSITION.—The most important constituent is the vegetable alkaloid *aconitina*, which is so poisonous that $\frac{1}{50}$th of a grain endangered the life of an individual. EFFECT.—The *topical* effects, when applied to the tongue, have already been mentioned. When small and repeated doses of the root or leaves are taken internally, they cause a sensation of heat, and a tingling in the extremities, and occasionally slight diuresis. In *poisonous* doses, the most remarkable effects are burning and numbness of the lips, mouth, and throat, extending to the stomach, and accompanied with vomiting, pricking, tingling, and numbness of the extremities, coldness and trembling of the limbs, confusion of the senses, with *contraction* of the pupils. USES.—Aconite is seldom used internally; but as a topical remedy, it is most valuable for the relief of neuralgic and rheumatic pains. In some cases the benefit is immediate and permanent; it may be applied in the form of a tincture of the root, or the extract may be made into an ointment with lard. The aconitina may likewise be applied dissolved in alcohol, or mixed with lard. Care must be taken that it be not applied where the skin is abraded. ANTIDOTES.—In the treatment of poisoning by aconite, the stomach must be speedily emptied; wine, ammonia, or brandy should be freely given, and, if necessary, perform artificial respiration.

ACORUS CALAMUS—*The Sweet Flag.*—*Sex. syst. Hexandria. Monogynia. Nat. ord. Acoraceæ.* HAB.—A native of this country, and grows in other countries of Europe, in Asia, and in the United States. PART USED.—The rhizome, or under-ground stem. EFFECTS AND USES.—It is an aromatic stimulant and mild tonic. It is seldom employed, but it is an useful adjunct to other stimulants and tonics. The dried root is used by the country people of Norfolk for the cure of ague. DOSE, ℈j. to ʒj. of the powdered rhizome.

ADEPS PRÆPARATUS—*Prepared Lard.*—Occasionally salt is added to lard to preserve it, but unsalted lard should be used for medical purposes. By melting in boiling water, lard may be deprived of any salt which may have been combined with it. USES.—Lard is chiefly employed as the basis of ointments; it is sometimes used as a substitute for spermaceti ointment to dress blisters; but the salt which lard frequently contains, as well as the facility with which this fat becomes rancid, are objections to its use.

ALLIUM.—*Sex. syst. Hexandria. Monogynia. Nat. ord. Liliaceæ.*—Two species of allium are used in medicine.

ALLIUM PORRUM—*The Leek.* PART USED.—The bulb. EFFECTS AND USES.—The leek is a stimulant and diuretic in ascites and other forms of dropsy.

ALLIUM SATIVUM—*The Garlic.* PART USED.—The bulb. EFFECTS AND USES.—Garlic is a local irritant. Internally it acts as a tonic, stimulant, diuretic, expectorant, and in large doses, emetic. It is sometimes used as a diuretic in dropsies, and as an expectorant in chronic catarrh.

ALOE—*The Aloe.*—*Sex. syst. Hexandria. Mono-*

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Materia Medica.

*gynia. Nat. ord. Liliaceæ.* Part used.—The inspissated juice of the leaves. The aloes of commerce is the produce of the *aloe vulgaris* and *aloe spicata.* Hab.—East and West Indies, and the Cape. Preparation.—The finest kind of aloes is obtained by evaporating the juice which flows spontaneously from the transversely-cut leaves. If pressure be employed, the proper aloetic juice becomes mixed with the mucilaginous liquid of the leaves, and thus an inferior kind of aloes is obtained. A still commoner variety is obtained by boiling the leaves in water. Varieties.—There are several varieties of aloes which have received the names of the places in which they are produced: of these the most important are the Socotorine, the Barbadoes, and the Cape aloes. The general appearances and properties of aloes are sufficiently well known to most persons; the distinction between the different varieties is of too little importance to occupy our attention in this treatise. Composition.—The analysis of aloes is far from being satisfactory. We are told that it contains a peculiar extractive matter, called *aloesin, aloetic acid,* and resin. Effects.—In small doses aloes act as a tonic to the alimentary canal, strengthening the muscular fibre, and assisting the digestive process. In large doses it acts as a purgative. The peculiarities attending the purgative operation of aloes are, 1st, its slow action; 2ndly, its acting especially on the large intestines; 3rdly, the power assigned to it of increasing the flow of bile. It is supposed to stimulate the uterus, thus tending to bring on or increase the menstrual discharge. Uses.—Aloes is used in cases of dyspepsia, in habitual costiveness, in cerebral affections to produce a revulsive effect as an anthelmintic, and to excite the menstrual discharge. It is an objectionable purgative when there is a tendency to hæmorrhoids, or to menorrhagia. Dose.—The ordinary dose of aloes is grs. x., but from grs. x. to grs. xx. are sometimes given. On account of its nauseous taste, it is commonly given in the form of pills. Aloes enters into the composition of many preparations of the Pharmacopœia. The *Pilula Aloes compositæ* contains aloes and extract of gentian, and is an useful tonic purgative in doses of from grs. v. to grs. xv. *Decoctum Aloes compositum* contains aloes, myrrh, and carbonate of potash. It is a valuable antacid and stomachic aperient. Dose, ℥ j. There are numerous other preparations of aloes, a knowledge of which may best be acquired by reference to the Pharmacopœia.

Althæa Officinalis—*Marsh Mallow.—Sex. syst. Monadelphia. Polyandria.—Nat. ord. Malvaceæ.* Hab.—Indigenous. Part used.—The root. Effects and Uses.—The root contains a large proportion of mucilage, and is used as a demulcent. The *Syrupus Althææ* is used as an adjunct to cough mixtures, and as a pectoral for children.

Alumen—*Alum.*—This salt is a compound of alumina, potassa, and sulphuric acid. Preparation.—The most extensive alum manufactory in Great Britain is at Hurlett, near Paisley. Here the aluminous schist (which is composed of sulphuret of iron and alumina) lies between the stratum of coal and limestone. By the action of the air it undergoes decomposition, and falls down on the floor of the mine. The sulphur attracts oxygen, and is converted into sulphuric acid, which combines partly with the iron (oxidized by the air) and partly with the alumina. The solution obtained by lixiviating the decomposed schist is evaporated, and the sulphate of iron allowed to crystalize: to the mother liquor, which contains sulphate of alumina, sulphate of potash is added, by which crystals of alum are procured. Composition.—Crystallized alum has the following composition:—Alumina, 3 eq., potassa, 1 eq., sulphuric acid, 4 eq., water, 25 eq. It crystallizes in regular octahedrons. Effects.—The topical effect of alum is that of an astringent, namely:—corrugation of the fibres, and contraction of the small vessels; hence it produces paleness of the parts, and checks exhalation and secretion. Internally it produces dryness of the mouth and throat, increases thirst, checks the secretions of the alimentary canal, and produces constipation. In large doses it acts as an irritant, and produces vomiting and purging. Uses.—Alum is used as a gargle for relaxed sore throat, to produce contraction or corrugation in cases of prolapsus ani. An injection is frequently used to check discharges from the mucous membranes, as in gonorrhœa and gleet. As a styptic, to constringe the capillary vessels, and close their bleeding orifices. As an internal remedy, it is given to restrain passive hæmorrhages, and to check profuse perspiration, or diarrhœa. It is said to have been very successful in the treatment of lead colic. Dose, from grs. x. to ℨ fs. Antidote.—Where an over-dose of alum has been taken, the best treatment is to promote vomiting by the free use of tepid diluents.

Ammoniæ Hydrochloras—*Hydrochlorate* or *Muriate of Ammonia.* Preparation.—Bones are subjected to the destructive distillation, and the volatile products are condensed in a cooled receiver. In this process various compounds are formed by the combination of the different gases. Thus we have carbon and oxygen uniting to form carbonic acid, which unites with the ammonia formed by the combination of nitrogen and hydrogen; and thus we obtain carbonate of ammonia. The carbonate is converted into sulphate of ammonia by adding sulphuric acid, or by digesting with sulphate of lime. The sulphate of ammonia is then mixed with chloride of sodium, and subjected to sublimation. Sulphate of soda remains in the retort, and hydrochlorate of ammonia sublimes. Properties.—This salt occurs in large translucent cakes; when heated it sublimes; mixed with potash or lime, it gives off ammoniacal gas. Composition.—Hydrochloric acid, 1 eq., ammonia, 1 eq. Effects.—Taken internally, it acts as a diuretic, and the Germans consider it a powerful alterative and resolvent. Uses.—It is seldom used in this country. In Germany it is used in cases of inflammation of the mucous and serous membranes, and in chronic visceral disease. Dr. Watson has frequently given it with success in cases of face-ache.—*Vide Med. Gaz.* vol. 28, p. 489. Externally, it is frequently employed on account of the cold produced during solution in cases of headache, mania, &c. Dose.—For internal uses, the dose is from grs. v. to ℨ fs., every four or five hours.

Liquor Ammoniæ—*Solution of Ammonia.* Preparation.—Put lime slaked with water into a retort, then add hydrochlorate of ammonia with water; let the solution of ammonia distil. In this process we have formed water, chloride of calcium, and ammoniacal gas, which is dissolved by, and distilled with, the water. Properties.—A colourless liquid, having a very pungent odour, and a caustic alkaline taste; prepared according to the London Pharmacopœia, its sp. gr. is 0·960. Effects.—In the concentrated form, the



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local action of liquor ammoniæ is that of an energetic caustic. Its vapours are very irritant, and when applied to the nostril, frequently rouse a person from the most death-like syncope. It should not be incautiously applied, as it may produce dangerous or even fatal inflammation of the larynx. Swallowed in large doses, it acts as a powerfully corrosive poison. The *remote effects* are a sensation of warmth, increased heat of skin, with a tendency to perspiration, and increased quickness of the pulse. There is increased secretion from the bronchial and urinary mucous membranes; the nervous system is also affected. There is increased capability of muscular exertion, and some excitement of the mental functions; these effects soon subside. USES.—To neutralize acidity in dyspepsia. Neither this nor any other alkali should be long continued, as it tends to render the urine alkaline, and favours the deposition of the phosphates, besides interfering with the digestive process by neutralizing the free acids of the stomach. Liquor ammoniæ is frequently used as a rubefacient and counter-irritant in cases of inflammatory sore throat, &c.: for this purpose there is a liniment of ammonia. It is sometimes applied to the surface of the chest, for the purpose of exciting the muscles of respiration in a case of asphyxia. It is given internally as a stimulant in a variety of cases where we wish to produce speedy excitement; for example, in fevers, syncope, poisoning by tobacco, foxglove, &c. DOSE.—From ♏ v. to ♏ xxx., properly diluted. ANTIDOTES.—The dilute acids, as vinegar, lemon, or orange juice: if these be not at hand, the dilute mineral acids, or oil in considerable quantities.

AMMONIÆ SESQUI-CARBONAS—*Sesqui-carbonate of Ammonia.* PREPARATION.—Hydrochlorate of ammonia and chalk are powdered, then mixed, and, with a heat gradually raised, sublimed. The carbonic acid leaves the lime, and combines with the ammonia; while the hydrochloric acid combines with the lime to form chloride of calcium and water. PROPERTIES.—Sesqui-carbonate of ammonia is in colourless translucent masses of a striated crystalline appearance; the smell is pungent, and taste sharp and penetrating. COMPOSITION.—1 eq. ammonia, $1\frac{1}{2}$ eq. carbonic acid, 2 eqs. water. EFFECTS AND USES.—The same as those of the liquor ammoniæ; it is, however, a much less powerful caustic than the liquor ammoniæ. DOSE.—As a stimulant and diaphoretic, from grs. v. to grs. x.; as an emetic, the dose is grs. xxx. ANTIDOTES.—The same as for the liquor ammoniæ.

LIQUOR AMMONIÆ ACETATIS—*Solution of Acetate of Ammonia*—prepared by saturating sesqui-carbonate of ammonia with distilled vinegar. PROPERTIES.—It should be colourless, and should affect neither litmus, nor turmeric. EFFECTS.—It is a mild diuretic and diaphoretic. USES.—It is given in febrile and inflammatory diseases, and forms a constituent of the ordinary saline draught. Externally, it is frequently used mixed with water, as an evaporating lotion to bruised and inflamed parts. DOSE.—f. ʒ ſs. to f. ʒ ij. every four hours.

There are three preparations called respectively—SPIRITUS AMMONIÆ, SPIRITUS AMMONIÆ AROMATICUS, and SPIRITUS AMMONIÆ FŒTIDUS.—Each of these contains the *carbonate of ammonia*, formed by the action of hydrochlorate of ammonia, or carbonate of potash. The aromatic spirit contains some cloves, cinnamon, and lemon-peel. The fœtid spirit contains assafœtida. Each of these preparations is stimulant and anti-spasmodic in doses of from ♏ x. to ♏ xl.

AMMONIACUM.—Vide *Dorema Ammoniacum.*

AMYGDALUS COMMUNIS—*The common Almond.*—*Sex. syst. Icosandria. Monogynia. Nat. ord. Amygdaleæ.* HAB.—The almond-tree is a native of Syria and Barbary; but it is now naturalized in the South of Europe, and even in England, where, however, the fruit seldom ripens. There are two varieties of the almond, distinguished from each other by the taste of the kernel of their fruit. The *sweet* almond has a sweet and bland taste, and contains a large proportion of fixed oil, with some gum, sugar, and albumen. The *bitter* almond contains less fixed oil and more albumen than the sweet almond, a volatile oil, and a portion of hydrocyanic acid. The volatile oil of bitter almonds, which contains hydrocyanic acid, is prepared from the cake remaining after the expression of the fixed oil, by submitting it to distillation with water. Neither the volatile oil nor the hydrocyanic acid pre-exist in the bitter almond: both are developed by the action of water and *emulsin* upon *amygdalin.* EFFECTS AND USES.—Sweet almonds, when triturated with water, form an emulsion which is used as an agreeable vehicle for more active medicines. The oil may be used for the same purposes as olive oil. *Bitter* almonds, in small quantities, act as irritants, causing vomiting and purging; in large doses, tremors, convulsions, insensibility, and death,—the effects arising from the presence of hydrocyanic acid. The volatile oil is a most potent poison, acting as rapidly and giving rise to the same symptoms as the ordinary hydrocyanic acid of the shops. The principal consumption of the bitter almond is by the cook and confectioner for flavouring and scenting. The employment of the oil for such purposes requires great caution, and is not unattended with danger. The oil is much used for scenting soap, and for other purposes of the perfumer. Bitter almonds are seldom employed by the medical practitioner, on account of the uncertainty of their composition and effects. They are applicable to all the uses of hydrocyanic acid. The volatile oil may be given in doses of a quarter of a drop to a drop and a half, in an emulsion. Its strength is variable, but in general it is at least four times that of the officinal acid. ANTIDOTES.—In a case of poisoning by the bitter almond, the treatment must be the same as for hydrocyanic acid.

ANETHUM GRAVEOLENS—*The Dill.*—*Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* HAB.—The dill is a native of Spain and Portugal, and is cultivated in this country. The seeds are the parts used in medicine; they are oval, concave on one side, convex and striated on the other, of a brown colour, and surrounded by a straw-coloured membranous expansion. They have an aromatic odour, and a warm and pungent taste; their properties depend on the volatile oil which they contain. EFFECTS AND USES.—Dill seeds are carminative and stomachic. They are useful in the treatment of flatulent colic in infants. DOSE.—The powdered seed may be given in doses of from grs. x. to ℈ j.

ANISUM.—Vide *Pimpinella Anisum.*

ANTHEMIS NOBILIS—*Common Chamomile.*—*Sex. syst. Syngenesia. Superflua. Nat. ord. Compositæ.* HAB.—The chamomile is indigenous. The flowers are the parts used in medicine: they have a strong and peculiar odour, and a bitter aromatic tase. COMPOSITION.—The chamomile flowers contain volatile oil, bitter extractive, and tannic acid. EFFECTS AND USES.—Chamomiles are

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aromatic tonics, increasing the appetite, and assisting digestion. In large doses they act as an emetic. Dose.—In powder grs. x. to ℈j. The infusion is the most convenient mode of administering them, in doses of from f. ℥ i. to f. ℥ ij.

Antimonii Potassio-Tartras—*Potassio-tartrate of Antimony.*—This salt is known by the common name of *tartar-emetic.* The details of the preparation of this, as of the other salts of antimony, are so complex as to be quite unintelligible without a lengthened description and the use of diagrams; as our limits will not allow of our entering into these details, we must refer our readers to Dr. Pereira's work on *Materia Medica*, or to Mr. Phillip's *Translation of the Pharmacopœia Londinensis.* We must content ourselves with the general statement, that this salt is formed by boiling the sesqui-oxide of antimony with the bitartrate of potassa. The water is then evaporated, and we obtain crystals of potassio-tartrate of antimony, which is a double salt, composed of one equivalent of tartrate of potash, one equivalent of bitartrate of antimony, with three equivalents of water. Properties.—Emetic tartar crystallizes in white, transparent, inodorous, rhombic octahedrons, whose lateral planes are striated. They dissolve in 14 or 15 parts of water at 60°.

Chemical Characteristics.—Heated in a porcelain or glass capsule it chars, showing it contains an organic substance (tartaric acid). If a stream of hydro-sulphuric acid gas be transmitted through a watery solution of emetic tartar, the latter becomes orange-red; if a small quantity of hydrochloric acid be then added, a flocculent orange-red precipitate (hydrated sesqui-sulphuret of antimony) takes place. This precipitate is to be collected and dried, and introduced into a green glass tube. Then transmit a current of hydrogen gas over it, and after a few minutes apply the heat of a spirit-lamp to the sesqui-sulphuret, and hydro-sulphuric acid and metallic antimony are produced. This metal is known to be antimony by dissolving it in nitro-hydrochloric acid: the solution forms a white precipitate on the addition of water, and an orange-red one with hydro-sulphuric acid gas. Purity.—The crystals should be well formed, colourless, transparent, or opaque, and when dropped into a solution of hydrosulphuric acid have an orange-coloured deposit formed on them. Emetic-tartar is sometimes adulterated with bitartrate of potash. In order to detect this, a few drops of a solution of carbonate of soda are to be added to a boiling solution of tartar-emetic, and if the precipitate formed be not re-dissolved, we may conclude there is no bitartrate present. Effects.—Applied to the skin in solution, or in the form of ointment, tartar-emetic produces an eruption of painful pustules very much resembling those of small-pox. *Internally*, in small doses, it increases the secretions of the gastro-enteritic mucous membrane, and of the liver and pancreas. Subsequently it acts powerfully on other emunctories: thus it causes sweating without any very evident vascular excitement; it renders the bronchial mucous membrane moister, and, when the skin is kept cool, promotes the secretion of urine. In larger doses it excites nausea, frequently with vomiting, depresses the nervous functions, relaxes the tissues (especially the muscular fibres), and occasions a feeling of great exhaustion. These symptoms are attended by increased secretion, especially from the skin. In excessive doses it has, in a few cases, acted as an irritant poison, and even produced death. A curious fact connected with this medicine is the large doses which are borne without any very obvious effects in many inflammatory diseases. In cases of pneumonia, many grains have been given in the course of 24 hours, without any other effect, after the first two or three doses, than the mitigation of the disease.

Use.—As an emetic, either alone or combined with ipecacuanha, when, in addition to the evacuation of the stomach, we are desirous of making a powerful impression on the system, whereby we hope to arrest some morbid process which may be going on. With this view it is given in the early stage of some fevers and inflammations, especially in croup, quinsy, swelled testicle, and bubo. As a *nauseant* it is frequently given to assist the reduction of dislocations of the larger joints in muscular subjects. It is also most valuable in the treatment of many inflammations, particularly those of the chest, and most especially those of the lungs. It is a most valuable sudorific in febrile and inflammatory diseases generally. As a local irritant it is used in chronic diseases of the chest and of the joints. Dose.—As a diaphoretic and expectorant, $\frac{1}{16}$ to $\frac{1}{8}$ of a grain; as a nauseant from $\frac{1}{4}$ to $\frac{1}{2}$ grain; as an emetic from 1 to 2 grains; as an antiphlogistic, from $\frac{1}{4}$ a grain to 3 or 4 grains. Antidote.—Promote vomiting by the copious use of tepid bland drinks.

Antimonii Oxy-sulphuretum — *Oxy-sulphuret of Antimony.*—This is a compound of sesqui-oxide and sesqui-sulphuret of antimony. Effects.—The same as those of tartar-emetic, but more uncertain. It is a constituent of the celebrated Plummer's pill, in which it is combined with calomel and guaiacum. Dose.—As a diaphoretic and alterative, from gr. j. to gr. iv.

Pulvis Antimonii Compositus—*Compound Powder of Antimony.*—This is a more uncertain preparation than the last. It sometimes acts most violently, and in other cases is quite inert. According to Phillips, it is composed of antimonious acid and phosphate of lime. Dose, grs. v. to grs. x.; it is but little employed.

Arctostaphylos Uva-ursi—*The Bear-berry.*—*Sex. syst. Decandria. Monogynia. Nat. ord. Ericaceæ.*—This plant is indigenous. The dried leaves are of a dark, shining green colour, and have a bitter astringent taste, but no odour. They contain tannic and gallic acid in considerable quantities. Effects and Uses.—Uva-ursi is an astringent and tonic, but it has an especial action on the urinary organs; it slightly increases the quantity of the renal secretion, and has the power of checking excessive secretion from the mucous membrane of the bladder. It is chiefly used in chronic affections of the bladder, attended with increased secretion of mucus, and unaccompanied with marks of active inflammation. Dose.—The powder may be given in doses of from ℈j. to ʒj. It is best given in the form of decoction or extract.

Argenti Nitras—*Nitrate of Silver.*—Preparation.—Silver is dissolved in nitric acid; the solution is afterwards evaporated to dryness, and the dried nitrate fused and poured into proper moulds. Chemical Characters.—It is known to be a nitrate by its deflagration when heated on charcoal, and the evolution of nitrous fumes. Dissolved in water it gives a white precipitate, with hydrochloric acid; this precipitate, by exposure to the light, becomes violet-coloured; it is insoluble in boiling nitric acid, but readily soluble in solution of ammonia. Oxalic acid gives a white preci-



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pitate with nitrate of silver; this precipitate, when dried and moderately heated, detonates.

EFFECTS.—Its local action is that of a caustic; it combines and forms insoluble compounds with albumen and fibrin; these are at first white, but afterwards become dark, and even black from the reduction of the silver. Internally administered, it is supposed to have a tonic and anti-spasmodic power, on account of the relief afforded by its use in some spasmodic diseases. One fact must never be lost sight of,—that when this medicine is given internally for a number of weeks, it becomes absorbed, and occasionally produces a blue colour of the skin, the metal becoming reduced by the action of light. USES.—It is said to have been more successful than any other remedy in the cure of epilepsy; but in most cases it entirely fails. It has been used with success in chorea. Its use as an external agent is more common and more valuable. It is used for destroying warts, and to repress spongy granulations. It is applied to chancres, on their first appearance, to decompose the syphilitic virus, and thus to prevent its absorption. It is applied to poisoned wounds. In some diseases of the eye it is used either in the solid form or in solution. It is used as an injection in gonorrhœa, gleet, and leucorrhœa, and in a number of other cases which we need not now enumerate. DOSE.—Nitrate of silver may be given internally in doses of from $\frac{1}{6}$ of a grain to iij. grs. three times a-day: on account of the danger of blackening the skin, its use should not be continued for more than a month or six weeks at a time. For external use a solution is employed, varying in strength from $\frac{1}{4}$ gr. to ℈ ij. in an ounce of distilled water. ANTIDOTE.—The antidote for nitrate of silver is common salt (chloride of sodium), which forms with it an insoluble chloride of silver.

ARGENTI CYANIDUM — *Cyanide of Silver.* PREPARATION.—Diluta hydrocyanic acid is added to a solution of nitrate of silver, the cyanide of silver becomes precipitated. USE.—It is used only for the extemporaneous preparation of hydrocyanic acid. — Vide *Acid hydrocyanicum.*

ARISTOLOCHIA SERPENTARIA—*Virginia Snake-Root.* —*Sex. syst. Gynandria. Hexandria. Nat. ord. Aristolochiaceæ.* HAB.—North America. PARTS USED.—The root. PROPERTIES.—The dried root has an aromatic odour, and a warm bitter pungent taste, which depends on the presence of a volatile oil. EFFECTS AND USES.—It is a stimulating diaphoretic and tonic; and is sometimes, but rarely, employed as a stimulant in continued and intermittent fevers. DOSE, grs. x. to ʒ j. The infusion is the best form for its administration.

ARMORACIÆ RADIX.—Vide *Cochlearia Armoracia.*

ARSENICUM—*Arsenic.*—The compound of arsenic which is used in medicine is the arsenious acid. It is obtained by sublimation from a compound of arsenicum, iron, and sulphur. The arsenic becomes volatilized, and combining with the oxygen of the air is condensed again in the form of arsenious acid. COMPOSITION.—Arsenious acid is composed of one equivalent of arsenic, and one and a half equivalent of oxygen. PROPERTIES.—When recently prepared, arsenious acid is in the form of large, glassy, transparent cakes, sometimes colourless, at others having a yellowish tinge. Sp. gr. about 3·7. Sparingly soluble in cold water, more abundantly soluble in boiling water. It is soluble in alcohol and oils. At a temperature of 380° Fahrenheit it volatilizes. CHEMICAL CHARACTERISTICS.—*Solid arsenious acid* is recognized by the following characters: 1st *its volatility.* 2nd. *Garlic odour.*—If arsenious acid be put on a red-hot cinder, it evolves a scarcely visible vapour (of metallic arsenicum) having a garlic odour, and which, at the distance of an inch or two from the cinder, is converted into a dense white colourless mass (arsenious acid). 3rd, *Formation of a metallic crust (reduction test).* —If arsenious acid be mixed with freshly ignited but cold charcoal, and heated in a glass tube, the acid is deoxidised, and yields arsenicum, which sublimes into the cooler portion of the tube, where it condenses and forms a metallic crust. The characters of the arsenical crust are the brilliancy of its outer surface; the crystalline appearance and greyish white colour of its inner surface; its volatility; its conversion by sublimation, up and down the tube, into octabedral crystals of arsenious acid, which may be dissolved in distilled water, and tested by the liquid re-agents presently to be mentioned.



CHARACTERS OF AN AQUEOUS SOLUTION OF ARSENIOUS ACID.

1. *Ammoniaco Sulphate of Copper.*—A dilute solution of this gives, with arsenious acid, a pale green precipitate (arsenite of copper), and sulphate of ammonia remains in solution. 2. *Ammoniaco-Nitrate of Silver* gives a yellow precipitate of arsenite of silver, and nitrate of ammonia remains in solution. 3. *Sulphuretted Hydrogen Gas* passed through a solution of arsenious acid gives a yellow precipitate of sesqui-sulphuret of arsenicum. 5. *Nascent Hydrogen.*—If arsenious acid be submitted to the action of nascent hydrogen, it is deoxidized, and the metallic arsenicum, thus produced, combines with the hydrogen and forms arseniuretted hydrogen gas. This gas is recognised by its alliaceous odour, by burning in the air with a bluish-white flame, and the deposition of black metallic arsenicum and white arsenious acid. Such is an outline of the characters of arsenious acid; but there are numerous fallacies, impediments, and precautions to be attended to in testing for this substance, for the details of which we would refer our readers to Dr. Christison's admirable work on *Poisons.* EFFECTS.—In very small doses arsenic relieves some diseases of the skin and nervous system without producing any other obvious effect on the functions of the body. If the small doses be long continued, symptoms of slow poisoning appear, commencing with thirst, redness of the conjunctiva and eyelids, disorder of the digestive functions, flatulence, pain in the abdomen, nausea, vomiting, sometimes purging: in some cases salivation occurs, quick pulse, hot skin, headache; sometimes an eruption appears on the skin; under these symptoms the patient may gradually sink. *In excessive doses* the symptoms are usually those of violent inflammation of the stomach and intestines pain, vomiting, and purging, with rapid sinking of the vital powers; symptoms of disorder of the nervous system usually precede death. In some cases, when very large quantities have been taken, death has occurred rapidly, with symptoms of *narcotism,* and without any marked symptoms of abdominal inflammation. In cases of poisoning by arsenic, the *post-mortem* appearances are chiefly those indicative of inflammation of the stomach and intestines.

Arsenious acid has the power of preventing or retarding the putrefactive process; hence the good state of preservation in which the alimentary canal has been found some months after death in persons poisoned by this substance. USES.—Arsenious acid is a valuable

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remedy in intermittent fevers, and in various chronic affections of the skin, particularly the scaly diseases (lepra and psoriasis). It has been used in some nervous diseases, as epilepsy and chorea, but with doubtful advantage. It is sometimes used as an external application to malignant ulcers, &c.; but this mode of using it has occasionally been followed by fatal consequences. Dose, gr. $\frac{1}{16}$ to gr. $\frac{1}{8}$, in a pill, with crumb of bread: the best mode of administering it is in the form of the *Liquor Potassæ Arsenitis*, the dose of which is ♏ v. gradually and cautiously increased. Antidotes.—Empty the stomach by the pump, or by an emetic of sulphate of zinc or sulphate of copper; promote vomiting by tepid and demulcent drinks; as milk, white of egg, and water-gruel, &c. Hydrated sesquioxide of iron has been proposed as an antidote; it must be given in very large doses.

Artemisia Absinthium—*Common Wormwood.*—*Sex. syst. Syngenesia. Polygamia. Superflua. Nat. ord. Compositæ.* Hab.—Indigenous. Parts used.—The tops. Composition.—Volatile oil and a bitter principle. Effects and Uses.—It is an aromatic tonic, and is said to be vermifuge, but it is seldom employed.

Asarum Europæum—*Asarabacca.*—*Sex. syst. Dodecandria. Monogynia. Nat. ord. Aristolochiaceæ.* Hab.—Indigenous. Part used.—The leaves. Composition.—Volatile oil, asarite, *camphor*, and a *bitter principle.* Effects and Uses.—Every part of the plant is very acrid; applied to the nose it excites sneezing, and an increased flood of mucus; swallowed, it excites vomiting and purging. It has sometimes been used as an *errhine*, three or four grains of the powdered leaves being snuffed up the nostril every night.

Assafœtida.—Vide *Ferula Assafœtida.*

Aspidium Filix Mas—*The Male Fern.*—*Sex. syst. Cryptogamia Filices, Nat. ord. Filices.* Hab.—Indigenous. Part used.—The rhizome. Composition.—Its anthelmintic property depends on a peculiar oil, which is soluble in ether. Effects and Uses.—It is employed only as an anthelmintic, and is not a remedy of much value. Dose.—Of powder from ʒ j. to ʒ iij. The oil may be given in the dose of from f. ʒ ſs. to f. ʒ j.

Astragalus Verus—*Tragacanth.*—*Sex. syst. Diadelphia. Decandria. Nat. ord. Leguminosæ.* Hab.—Asia. Tragacanth is a natural exudation from the stem of the plant. Composition.—Soluble and insoluble gum and starch. Effects.—Emollient, demulcent, and nutritive. Uses.—As a vehicle for more active medicines, and as a sheathing or demulcent agent in irritation of the mucous membranes.

Atropa Belladonna—*Deadly Night-shade*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Solanaceæ.* Hab.—Indigenous. Part used.—Leaves and root. Composition.—Its properties depend on an alkaloid called *Atropia.* Effects.—In small doses belladonna diminishes sensibility and irritability. In the *second degree* of its operation it causes dilatation of the pupils, dimness of sight, numbness of the face, confusion of the head, and delirium, which at times resembles intoxication, and may be combined with, or followed by torpor. There is dryness of the throat, and difficulty of swallowing, and of articulation; the mucous secretions are frequently increased; an eruption like that of scarlet fever has been noticed. In the *third degree* of its operation, belladonna produces effects similar to the preceding, but in a more violent form; when applied to the eyebrow, belladonna produces dilatation of the pupil. Uses.—To allay pain and nervous irritation, to relieve spasm, to produce dilatation of the pupil in diseases of the eye, to resolve tumors. By the homœopathist, it has been used as a prophylactic against scarlatina. Dose.—The *powder* may be given in one-grain doses. The *extract* is prepared by bruising the fresh leaves, sprinkled with a little water, in a stone mortar; then press out the juice and evaporate it, unstrained, to a proper consistence. Dose.—gr. j. to grs. v. The extract is often useful, when locally applied, in relieving rheumatic and neuralgic pains. Antidotes.—Similar to those for opium.

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Balsamodendron Myrrha—*The Myrrh Tree.*—*Sex. syst. Octandria. Monogynia. Nat ord. Terebinthaceæ.* Hab.—Gison, on the borders of Arabia Felix. Myrrh exudes from the bark of the tree: it is at first soft, and of a yellow colour, but, by drying, becomes darker and redder. Composition.—The chief constituents of myrrh are volatile oil, resin, and gum. Effects and Uses.—Myrrh is an aromatic stimulant and tonic; it has been supposed to have a specific stimulant operation on the uterus, and hence has been called emmenagogue. It is given in cases of debility, amenorrhœa, and chlorosis, and in certain stages of phthisis. Dose—grs. x. to ʒ ſs. Myrrh is a constituent of several pharmacopœial preparations.

Balsamum Peruvium—Vide *Myrospermum Peruiferum.*

Balsamum Tolutanum—Vide *Myrospermum Toluiferum.*

Barytæ Carbonas—*Carbonate of Baryta.*—This salt is found native. Use.—It is not used as a medicine, but is employed in the preparation of the chloride of barium.

Barii Chloridum—*Chloride of Barium.* Preparation.—Add dilute hydrochloric acid to carbonate of baryta, apply heat, and when the effervescence has ceased, strain and boil down, that crystals may form. Characteristics.—The salts of baryta give, with sulphuric acid, a white precipitate, insoluble in water and in nitric acid. Composition.—1 eq. barium, 1 eq. chlorine, with which are combined in the crystals 2 eq. water. Effects.—In small doses chloride of barium increases the secretion of urine and of perspiration, and at the same time glandular swellings sometimes become softer and smaller. In larger doses it produces nausea and vomiting, and in excessive doses it acts strongly on the nervous system, producing headache, convulsions, and death within an hour. Use.—It has been chiefly used in the treatment of scrofula. Dose.—It is used in the form of aqueous solution. The *liquor barii chloridi* consists of a drachm of the salt in an ounce of water; the dose is ♏ s. In chemistry this salt is used as a test for sulphuric acid and the sulphates. Antidotes.—The sulphates, which form an insoluble sulphate of baryta.

Belladonna.—Vide *Atropa Belladonna.*

Benzoinum.—Vide *Styrax Benzoin.*

Bistorta.—Vide *Polygonum Bistorta.*

Bismuthi Trisnitras—*Trisnitrate of Bismuth*—prepared by dissolving bismuth in nitric acid: water is then added, and the trisnitrate precipitates. Composition.—3 eqs. of oxide of bismuth and 1 eq. of nitric acid. Effects.—In small doses it acts as an astringent; it is supposed to have a sedative effect on the nerves of the stomach; it has also been considered tonic and anti-spasmodic. In large doses it is poisonous. Use.

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—Its chief use is to relieve gastrodynia and cramp of the stomach, to allay sickness and vomiting, and as a remedy for the water-brash. Dose, grs. v. to ℈ j., in the form of a pill.

BROMINIUM—*Bromine.* PREPARATION.—It is prepared from the mother liquor of some springs, which contain the bromids of potassium in solution: binoxide of manganese and hydrochloric acid are added, and heat applied, the bromine is set free, and distils over. PROPERTIES.—At ordinary temperatures, bromine is a very volatile liquid, which, seen by reflected light, is blackish red, but by transmitted light is hyacinth red. Its odour is strong and taste acrid. It communicates a fine orange-colour to starch. EFFECTS.—Bromine stains the cuticle yellowish brown, and acts as an irritant. Its vapour is also very irritating. The constitutional effects are analogous to those of iodine. USES.—It is used in the same cases as iodine, than which it is usually regarded as possessing more activity. DOSE.—One or two drops dissolved in water.—Vide *Potassii Bromidum.* ANTIDOTES.—The same as for iodine.

CAJUPUTI OLEUM.—Vide *Melaleuca Minor.*

CALAMINA.—Vide *Zincum.*

CALUMBÆ RADIX.—Vide *Cocculus Palmatus.*

CALX—*Lime.* PREPARATION.—Chalk is exposed to a very strong fire during an hour, by which the carbonic acid is expelled. PROPERTIES.—Lime, when pure, is a white solid; it has an acrid, alkaline taste, and re-acts powerfully on vegetable colours as an alkali; exposed to the air it attracts water and carbonic acid. If a small portion of water be added to lime, part of it combines with the lime, with a considerable evolution of heat. The lime swells up and falls to powder: in this state it is called *slaked lime*, or the *hydrate of lime.* Lime dissolves in water, forming *lime-water*, or *aqua calcis.* It is remarkable that water at 32° dissolves nearly twice as much lime as water at 212°. CHARACTERISTICS.—Lime-water is recognized by its action on turmeric paper, and by the precipitate produced by adding carbonic or oxalic acid, or the salts of these acids. EFFECTS.—Quick-lime is an escharotic; Lime-water is a local astringent; internally it is antacid, astringent, diuretic, and alterative. USES.—As an antilithic in the lithic acid diathesis, as an antacid in dyspepsia, and as an astringent wash to ulcers attended with excessive secretion. DOSE.—Lime-water may be given in doses of from f. ℥ ſs. to f. ℥ iv. three times a day.

CALCII CHLORIDUM—*Chloride of Calcium.* PREPARATION.—Add hydrochloric acid to carbonate of lime; when the effervescence has ceased, the filtered solution is evaporated, and the residue fused in a crucible; while in the liquid state it is to be poured on a clean flat stone, and, when cold, broken into small pieces, and preserved in a well-stopped vessel. PROPERTIES.—A white translucent solid, having a bitter and acrid saline taste; it has a great attraction for water, and deliquesces in the air. EFFECTS.—Much the same as those produced by chloride of barium. USES.—Chiefly in scrofula, attended with glandular enlargements. In pharmacy it is used in the rectification of spirit, on account of its strong affinity for water. DOSE.—It is given in the form of aqueous solution. The liquor calcii chloridi, consists of four ounces of the chloride dissolved in twelve fluid ounces of distilled water. The dose is ♏ xl., or ♏ l.

CALCIS HYPOCHLORIS—*Hypochlorite* or *Chloride of Lime.* PREPARATION.—It is prepared by conveying chlorine gas into a vessel or chamber containing slaked lime. PROPERTIES.—Chloride of lime is a brownish white powder, having a feeble odour of chlorine, and a strong bitter and acrid taste; exposed to the air it evolves chlorine and attracts carbonic acid. Its solution in water has bleaching properties. COMPOSITION.—Chemists are not agreed as to its exact nature. It is probably a mixture of chloride of calcium and hypochlorite of lime. EFFECTS.—Its local action is that of an irritant and desiccant; when the secretions are excessive and fœtid, it diminishes their quantity and improves their quality. Internally it acts as an alterative, stimulant, and antiseptic. USES.—Extensively used as a disinfectant and antiseptic; when exposed to the air in sick chambers, it slowly evolves chlorine, and has a remarkable power of destroying unpleasant odours. Its power of destroying infection or contagion is, however, more doubtful; indeed some experiments which have been made seem to prove that it really has no such power.—Vide Pereira's *Mat. Med.* Chloride of lime is very useful when locally applied in checking the putrefactive process, and in correcting the unpleasant odour of putrid discharges. It is also given internally with great benefit in putrid fevers, especially in malignant scarlatina; a strong solution is said to be very successful in the cure of itch. Dose, gr. j. to grs. vj.

CALCIS CARBONAS—*Carbonate of Lime.*—It exists native in great abundance, as chalk, marble, &c. For medicinal purposes, *prepared chalk* is freed from impurities, and reduced to a finely divided state by the process of elutriation. PROPERTIES.—It is a tasteless, odourless solid, and requires 1600 parts of water to dissolve it. It is more soluble in carbonic acid water; by heating such a solution, the carbonic acid escapes, and the carbonate of lime is deposited. COMPOSITION.—1 eq. carbonic acid, 1 eq. lime. EFFECTS.—Chalk is an absorbent, antacid, and astringent. USES.—As a desiccant in some cutaneous diseases. Internally as an antacid in dyspepsia and an astringent in diarrhœa. It is a convenient antidote in cases of poisoning by the strong acids. Dose, grs. x. to ℨ j. It enters into the composition of a considerable number of officinal preparations.

CAMBOGIA.—Vide *Hebradendron Cambogioides.*

CAMPHORA OFFICINARUM—*The Camphor Tree.*—*Sex. syst. Enneandria. Monogynia. Nat. ord. Lauraceæ.* HAB.—China, Japan, and Cochin China. EXTRACTION.—The roots and wood of the tree, chopped up, are boiled with water in an iron vessel, to which an earthen head containing straw is adapted. The camphor sublimes and condenses on the straw. The crude camphor thus procured is refined by a second sublimation. PROPERTIES.—Refined camphor is met with in large hemispherical cakes. It is translucent, having a peculiar aromatic odour, and an aromatic bitter taste. It evaporates in the air at ordinary temperatures; but in closed vessels, exposed to light, sublimes and crystallizes on the sides of the bottle. Its specific gravity is ·985. It is very slightly soluble in water, but readily soluble in alcohol. COMPOSITION.—$C_{10}$ $H_8$ O. EFFECTS.—Camphor is stimulant, diaphoretic, and narcotic; its stimulant action is very transitory, and soon followed by sedative effects. It becomes absorbed, acting on the nervous system, and escaping by transudation through the skin and mucous membrane of the lungs. In moderate doses it operates as a cordial, increasing the heat of the body, rendering the pulse fuller, and promoting diapho-

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resis; in larger doses it allays irritation, pain, and spasm, and induces sleep. In very large doses it produces vomiting, delirium, convulsions, and other noxious effects. Uses.—As a cordial in typhoid fevers and the latter stages of some inflammatory diseases, also in some forms of mania and melancholia. As a sedative in some spasmodic diseases, and in irritation of the urinary and sexual organs. It is sometimes applied externally as an anodyne or local stimulant. It is a mistake to suppose that camphor bags have any prophylactic power against contagion. Dose—from grs. iij. to grs. x. or more. It is best given in the form of emulsion. *Mistura Camphoræ* is a solution of camphor in water, with a little rectified spirit. *Tinctura Camphoræ* is a solution of camphor in rectified spirit, the dose is ♏ x. to f. ʒ j. *Tinctura Camphoræ Composita*, in addition to camphor, contains opium, benzoic acid, and oil of anise. It is much used to allay cough unattended by inflammatory symptoms. Dose, f. ʒ j. to f. ʒ iij. Antidotes.—Evacuate the stomach, and subsequently give brandy or wine as a stimulant.

Canella Alba—*Canella Bark.* Hab.—West Indies and continent of America. Part used.—The bark. Description.—It occurs in quills, which are hard, of a yellowish white colour, somewhat lighter on the inner surface, and have an aromatic clove-like odour and an acrid peppery taste. Composition.—The most important constituents are *volatile oil*, *resin*, and *bitter extractive matter*. Effects.—Aromatic, stimulant, and tonic. Uses.—Chiefly as an aromatic addition to purgatives and tonics in dyspepsia and debility. Dose, from grs. x. to ʒ ſs.

Cantharis Vesicatoria—*The Blistering Fly.—Cl. Insecta, Ord. Coleoptera.* Hab.—South of Europe. They are found on species of *Oleaceæ* and *Caprifoliaceæ*. The insect is two-thirds of an inch long and one-fourth of an inch broad, of a green, gold-shining colour; with long flexible elytra or wing-sheaths, marked with three longitudinal raised stripes, and covering brown, membranous, transparent wings. The body is terminated by two small sharp spines, and on the head are two black pointed feelers. They are caught during the month of May by spreading large cloths under the trees, which are then strongly shaken or beaten with long poles. They are killed by steams of boiling vinegar, and dried either by the sun or in a stove. Composition.—The active properties of cantharides depend on a principle called *cantharidin*, which is a solid, crystallizing in micaceous plates, fusible, vaporizable, soluble in ether and hot alcohol. Effects.—The topical effects of cantharides are those of a powerful irritant. Applied to the skin, the first effects are a sensation of heat, with pain, redness, and swelling. Subsequently serum is effused, and raises the epidermis, forming a *blister*. Internally, in small doses, it produces a sensation of warmth in the stomach, and after a time a tickling sensation in the urethra, with frequent desire to pass the urine, which is often increased in quantity. In larger doses it produces great pain in the loins and bladder, the urine being often bloody and passed with difficulty. In very large quantities the symptoms produced are those of violent inflammation of the intestinal canal, followed by those of excessive irritation of the urinary organs. Occasionally the sexual feelings are excited by the use of cantharides. Abortion has sometimes been the consequence of a large dose. The external application of cantharides is sometimes followed by pain in the bladder, and difficulty in passing the water. Uses.—The chief use of cantharides is for external application to produce rubefaction and vesication in a number of cases which it would be tedious to enumerate: for this purpose the *Emplastrum Cantharidis* is generally employed. When a speedy blister is required, the *Acetum Cantharidis* is very useful. Internally they are sometimes given as a diuretic in dropsy, as a stimulant to the bladder in some cases of incontinence, and it is also an useful remedy in some chronic cutaneous diseases. For internal use the *tincture* is usually given in doses of from ♏ x. to ʒ j.

The powdered cantharides may be given in doses of one or two grains in the form of pill. Antidote.—Remove the poison as soon as possible by the stomach-pump, or by emetics, or by tickling the throat. Assist the vomiting by the copious use of mucilaginous and albuminous demulcent drinks. No chemical antidote is known.

Capsicum Annuum—*Capsicum or Cayenne Pepper.—Sex. syst. Pentandria. Monogynia. Nat. ord. Solanaceæ.* Hab.—America. Cultivated in England. Part used.—The dried fruit. Composition.—Its properties depend on the presence of an acrid volatile liquid, soluble in ether, which is called *capsicin*. Effects.—Applied to the skin, capsicum produces rubefaction and vesication. Internally it is an aromatic stimulant. Uses.—It is much used as a condiment. In medicine it is chiefly used as a local stimulant to the mouth, throat, and stomach. As a general stimulant it is of little value, its constitutional not being in any degree proportioned to its topical effects. It forms a valuable gargle in relaxed sore throat, and an useful stimulant in atonic dyspepsia. Dose.—The *powder* may be given in doses of from gr. v. to gr. x. The dose of the *tincture* is from ♏ x. to f. ℈ j.

Carbo-Animalis—*Animal Charcoal*—prepared by burning bones, and removing the carbonate and phosphate of lime by maceration in dilute hydrochloric acid. We thus obtain charcoal in a very finely divided state.

Carbo Ligni—*Wood Charcoal.*—For medicinal purposes it is procured by heating wood in iron cylinders, the gaseous products being allowed to escape. Properties.—Charcoal has the property of removing certain organic colouring matters, and various odorous matters from liquids in which they are dissolved. Another property is that of condensing within its pores a certain volume of any gas with which it may be brought in contact. The decolorizing power is possessed in a more eminent degree by animal charcoal; this is supposed to arise from the minute separation of the carbonaceous particles effected by the presence of other matters, as of phosphate of lime when bones are employed. Effects.—Charcoal appears to produce no evident effect on a healthy individual. Uses.—It is sometimes added to poultices to absorb the fœtid odour of sloughing ulcers; and internally it has been employed in dysentery to correct the fœtor of the evacuations. As a tooth-powder it is a valuable agent. It is said to have been given with success in intermittent fever. The chief use of the animal charcoal is for the decolorization of the vegetable alkaloids, as morphia, quinia, &c. Dose, grs. x. to a table-spoonful or more.

Cardamomum.—Vide *Elettaria Cardamomum.*

Carum Carui—*The Caraway.—Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* Hab.—All over Europe. Naturalized in England. Parts used.—

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The mericarps, commonly called the seeds. Composition.—Its aromatic qualities depend on a volatile oil. Effects and Uses.—An aromatic stimulant and carminative. It is useful in relieving flatulent colic, and is added as a corrective to several other medicines. Dose.—It is usually given in the form of the oil, spirit, or water. The dose of the oil is ♏ j. to ♏ x.

Caryophyllus Aromaticus—*The Clove Tree.*—*Sex. syst. Icosandria. Monogynia. Nat. ord. Myrtaceæ.*—Hab.—East India Islands. Parts used.—The clove is the unexpanded flower, the corolla forming a ball at the top between the four teeth of the calyx. Composition.—*Volatile oil, resin,* and *tannin* are the most important constituents of cloves. Effects and Uses.—The same as those of the caraway. An infusion of cloves forms an agreeable aromatic stomachic, in doses of from f. ʒ i. to ʒ ij.

Cascarilla.—Vide *Croton Eleuteria.*

Cassia Fistula—*The Purging Cassia.*—*Sex. syst. Decandria. Monogynia. Nat. ord. Leguminosæ.*—The *pulp* is obtained by pouring boiling water upon the bruised pods, pressing, filtering, and evaporating the water until the pulp acquires a proper consistence. Composition.—The chief constituent of the cassia pulp is sugar. Effects and Uses.—In small doses it is laxative, in larger ones purgative, occasioning nausea, flatulence, and griping. Dose, from ʒ j. to ʒ j.

Cassia Lanceolata, C. Obovata, C. Acutifolia, C. Elongata—*Senna.*—These species of cassia, which yield the senna of commerce, are natives of Upper Egypt, Central Africa, and India. Senna leaflets vary in shape as yielded by the various species; but they all resemble each other in being unequal at the base. This will serve to distinguish senna leaflets from the various leaves with which they are commonly adulterated. The most serious adulteration consists in the substitution of the leaves of *Coriaria Myrtifolia* for those of senna. These leaves are ovate-lanceolate, three-nerved, with a strongly marked mid-rib. Chemically, they are distinguished by their infusion yielding with gelatine a whitish precipitate (*tannate of gelatine*), and with sulphate of iron a very abundant blue precipitate (*tannate of iron*). Another adulteration consists in adding the leaves of *Cynanchum Argel* to those of the senna. Argel leaves are distinguished by being equal sided, by the absence of lateral nerves, by their pale colour and coriaceous texture, and by their greater length. The greater part of the senna of commerce is imported from Alexandria. The Tinnevelly Senna consists of the leaflets of Cassia Elongata, and is considered very fine, and free from adulteration. Composition.—Senna contains a peculiar principle called *cathartin*, soluble in water and alcohol. This is the purgative principle of senna. Effects.—Senna is a certain and safe purgative. Its ill effects are nausea, griping, and flatulence. It is one of the mildest of the drastic purgatives. If infusion of senna be given to the nurse, the sucking infant becomes purged. Uses.—Senna is adapted for those cases which require an active and certain purgative, with a moderate stimulus to the intestines; for example, in habitual constipation, in worms, and in determination of blood to the head. Dose.—Powdered senna may be given in doses of from ʒ ſs. to ʒ ij. *Infusum Sennæ Compositum* is made with senna, ginger, and boiling water; the dose is from f. ʒ ij. to f. ʒ iv. *Tinctura Sennæ Composita*, contains senna, caraway, cardamom, raisins, and proof spirit. The dose is from f. ʒ ij. to f. ʒ j. The *syrup* and the *confection* of senna are sometimes used.

Castor Fiber—*The Beaver.*—*Cl. Mammalia. Ord. Rodentia.* Hab.—North America and the North of Europe. Source of Castor.—Between the anus and the external genitals are four follicles; the two smaller are filled with a fatty substance, while the two larger contain each about two ounces of an oily, strong-smelling substance, which is the officinal castor. The follicles are cut off entire and dried. The best comes from Russia; but the greater part of that found in the shops is the produce of Canada. Composition.—The most important constituents are *volatile oil, castorine,* and *resin*. Effects and Uses.—Castor is denominated a stimulant and antispasmodic. Formerly it was much used in spasmodic diseases, as hysteria and epilepsy. It is now considered almost inert, and is seldom employed. Dose, ℈ ij.

Centaurium. Vide *Erythræa Centaurium.*

Cephaelis Ipecacuanha—*The Ipecacuanha.*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Rubiaceæ.*—Hab.—South America. Part used.—The root. Composition.—Ipecacuanha contains about 15 per cent. of a principle called *emetin*, very minute doses of which produce vomiting. Effects.—The powder of ipecacuanha, when inhaled, sometimes produces great difficulty of breathing, and symptoms similar to an attack of asthma. Internally, in small doses, it increases the secretion of the bronchial mucous membrane, and acts as an expectorant. In somewhat larger doses it produces nausea, and if the skin be kept warm, diaphoresis. In full doses it excites vomiting, followed by drowsiness. It is a very safe emetic, since an overdose will not give rise to inflammation. Uses.—As an *emetic* it is given in some cases of poisoning, in gastric disorders, as a counter-irritant at the commencement of fevers, and in many inflammatory disorders. As a *nauseant, diaphoretic,* and *expectorant*, it is given in affections of the respiratory organs. Thus an attack of croup may frequently be cut short by continued nauseating doses of ipecacuanha. It has also gained great celebrity for its influence over dysentery. In various other maladies, ipecacuanha is given as a sudorific, combined with opium. Dose.—As an emetic, about grs. xv. is usually given. As a nauseant, from gr. j. to gr. iij. As an expectorant and sudorific, the dose is gr. j. Vinum Ipecacuanhæ—(Ipecacuanha, bruised, ʒ ij. ſs., Sherry wine, O ij. Macerate for fourteen days, and strain). Dose.—As a diaphoretic and expectorant, ♏ x. to ♏ xl.; as an emetic, f. ʒ ij. to f. ʒ iv. For children, the dose as an emetic is from ♏ xx. to f. ʒ j.; according to the age of the child. Pulvis Ipecacuanhæ Compositus—*Dover's Powder*—(Ipecacuanha, powdered; hard opium, powdered, of each ʒ j.; sulphate of potash, powdered, ʒ j., mix them). This is one of our most certain, powerful, and valuable sudorifics in doses of from grs. v. to grs. x.

Cerevisiæ Fermentum—*Yeast.*—This is the scum or frothy matter which collects on the surface of beer while fermenting. It is chiefly composed of gluten in a certain state of decomposition. It also contains some alcohol and carbonic acid. Effects and Uses.—Yeast is considered to be tonic and antiseptic. Its chief use is as an external application to foul and sloughing ulcers. It corrects the fœtor of the discharge, and promotes the formation of healthy pus. The *Cataplasma Fermenti* is a mixture of flour and yeast. Its

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efficacy is supposed to depend on the evolution of carbonic acid gas during the fermentation occasioned by the presence of the yeast.

CERVUS ELAPHUS.—*The Stag.—Cl. Mammalia. Ord. Ruminantia.* HAB.—Europe, Asia, and North of Africa. PART USED.—The shavings or raspings of the horns. COMPOSITION.—*Gelatine, carbonate* and *phosphate of lime.* EFFECTS AND USES.—Decoction of hartshorn is nutrient, emollient, and demulcent. Hartshorn shavings are directed to be used in the manufacture of *Antimonial Powder. Cornu Ustum.*—Burn pieces of horn in an open vessel until they become perfectly white; then powder and prepare them by *elutriation.* In this process the animal matter is burnt away, leaving the earthy salts. USES.—Burnt hartshorn has been given in rickets with the view of promoting the deposition of bone-earth in the bones.

CETACEUM.—Vide *Physeter Macrocephalus.*

CETRARIA ISLANDICA.—Vide *Lichen.*

CHIMAPHILA UMBELLATA.—*The Winter Green.—Sex. Syst. Decandria. Monogynia. Nat. ord. Pyrolaceæ.* HAB.—Europe, Asia, and North America. PARTS USED.—The leaves and stems. COMPOSITION.—It contains *bitter extractive, resin,* and *tannin.* The active principle has not been isolated. EFFECTS.—An infusion of the dried leaves acts as a tonic and diuretic. Its action is analogous to that of the uva ursi. USES.—It is used as a diuretic in dropsies attended with debility. It has been found useful in chronic inflammation and catarrh of the bladder, and in scrofula. *Decoctum Chimaphilæ.*—Chimaphila ℥ j. water O i. ſs., boil down to a pint and strain. Dose, f. ℥ j. to f. ℥ ij.

CINCHONA.—*Several species yielding Peruvian Bark.—Sex. syst. Pentandria. Monogynia. Nat. ord. Rubiaceæ.*—Dr. Lindley mentions twenty-six species of cinchona, of which twenty-one are well known. The London Pharmacopœia, on the authority of Mutis, assumes that the three kinds of bark found in the shops are furnished by three distinct species, namely, *C. lancifolia, C. cordifolia,* and *C. oblongifolia.* There is much reason to doubt the accuracy of this arrangement. HAB.—The cinchona species inhabit the Andes, from 11° N. lat. to 20° S. lat., at varying elevations. BARK-PEELING.—The mode of obtaining the bark varies in different districts. In some parts the trees are cut down before the peeling is performed; but in other districts the bark is removed while the trees are standing. Cinchona is imported from various parts of the Pacific coast of South America. There are three kinds of genoine cinchona barks in English commerce,—the *pale,* the *yellow,* and the *red. Pale barks* have the following properties: They always occur in quills, never in flat pieces; their powder is more or less pale, greyish, or fawn-coloured, and their taste is astringent and bitter. They contain *cinchonia* and *quinia. Yellow bark* occurs in quills or flat pieces, the quills being generally larger and rougher than the quills of pale barks; the texture is more fibrous, and the taste more bitter and less astringent than that of pale bark; the powder is orange or fawn-yellow. It contains both quinia and cinchonia, but the first in by far the larger quantity. *Red bark* is met with in both quills and flat pieces; it has a fibrous texture and a redder colour than either of the preceding varieties; it contains both quinia and cinchonia; it is very bitter and astringent; its powder is more or less red. COMPOSITION.—The various kinds of cinchona bark contain variable proportions of the two alkalies, cinchonia and quinia, in combination with kinic acid. A third alkali was discovered in *arica cinchona,* by Pelletier and Carinl, in 1829; to this they gave the name of *Aricina.* These barks also contain tannin, colouring matter, various salts, &c. According to Goebel,* one pound of the best pale bark contains 168 grs. of cinchonia. The same quantity of the best yellow barks contains from 60 grs. to 95 grs. of quinia, and an equal amount of the true red barks contains from 20 grs. to 65 grs. of cinchonia, and from 16 grs. to 40 grs. of quinia. Cinchonia, quinia, and aricina may be considered as oxides of a common base (composed of $C_{20}H_{12}N$), which has been termed quinogen. According to this hypothetical view, cinchonia is a *monoxide,* quinia a *binoxide,* and aricina a *teroxide* of quinogen. The chemical tests for the goodness of cinchona barks are those which detect the tannic acid, and those which detect the vegetable alkalies. EFFECTS OF THE CINCHONA BARKS.—The topical effects are astringent and slightly irritant; the constitutional effects in some conditions of the system are those of an irritant or stimulant, in others those of a stomachic, tonic, and corroborant. The irritant and stimulant effects of cinchona are best seen when a full dose is given to a healthy person, or a moderate dose to a person labouring under gastro-enteritic irritation accompanied with fever. In such cases it produces disorder of the alimentary canal, with thirst, vomiting, headache, and great febrile disturbance. The tonic effects are evident in persons suffering from debility without local irritation. In such cinchona improves the appetite, promotes the digestive functions, and increases the strength. Cinchona, in addition to its general tonic properties, has the power of arresting the progress of periodic diseases. The efficacy of cinchona barks doubtless depends on the presence of the alkaloids. EFFECTS OF THE CINCHONA ALKALOIDS.—The effects of the alkalies do not differ from those of the bark, except in being more energetic. In large doses, the sulphate of quinia produces irritation of the stomach and intestines, excitement of the vascular system, and disorder of the fonctions of the brain and spinal chord. There appears no difference in the operation of quinia and cinchonia. It has been asserted that the cinchona alkalies possess all the medicinal properties of the barks, and may be substituted for them on every occasion. This, however, is incorrect, as in some cases the astringent and aromatic properties of the barks give them an advantage over the simple alkalies. In some cases, however, the alkalies are of great advantage, since they enable us to obtain, in a small volume, the tonic operation of a large quantity of bark. USES.—Cinchona is a most valuable tonic in all cases in which the use of tonics is indicated. But the great value of cinchona consists in the power which it possesses in arresting periodic or intermittent diseases. It is the best remedy for intermittent fever. In this disease we may give very large doses of the remedy a few hours before the expected paroxysm, or we may gradually extinguish the disease by the exhibition of moderate doses at short intervals during the whole period of the intermission. Cinchona is also useful in other intermittent diseases, as neuralgia, rheumatism, headache, &c. Cinchona is a valuable remedy in the latter stages of continued fevers, and of inflammatory diseases, and in maladies

* Vide Dr. Pereira's *Materia Medica.*



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characterized by stony and debility. MODE OF ADMINISTRATION.—The powdered bark may be given in doses of from ℈ j. to ʒ j. or more; but it is apt to occasion nausea. The infusion or decoction may be given in doses of f. ℥ j. or f ℥ ij. three times a day. There is a *simple* and a *compound tincture*, the dose of which is from f. ʒ j. to ʒ iij. The dose of the extract is from gr. v. to gr. xx. QUINIÆ DISULPHAS.—The process for obtaining this salt is somewhat complicated. The following is an outline of the process:—By boiling yellow bark in water we obtain a solution of *kinate of quinia;* when ammonia is added to this, the quinia is precipitated, and kinate of ammonia remains in solution. The quinia is then saturated with sulphuric acid; we thus obtain disulphate of quinia, the composition of which is one equivalent of sulphuric acid and two equivalents of quinia. Disulphate of quinia may be given in doses of from gr. j. to gr. v.; larger doses are sometimes given as a febrifuge, but they are apt to disorder the stomach. It may be given in the form of a pill, or in solution with an acid, as in the compound infusion of roses.

CINNAMOMUM ZEYLANICUM—*The Cinnamon.—Sex. syst. Enneandria. Monogynia. Nat. ord. Lauraceæ.* HAB.—Ceylon and Java. PART USED.—The bark of the small branches. COMPOSITION.—*Volatile oil, tannin, mucilage,* and *resin* are the most important constituents. EFFECTS AND USES.—Cinnamon produces the usual effects of an aromatic stimulant and tonic; it is also slightly astringent. It is much used as a condiment, and in medicine combined with other tonics and astringents. DOSE.—The powder may be given in doses of from grs. x. to ʒ fs. In the Pharmacopœia we have *Aqua Cinnamomi*, the *Tinctura Cinnamomi*, *Tinctura Cinnamomi Composita*, *Oleum Cinnamomi*, and *Spiritus Cinnamomi*.

CISSAMPELOS PAREIRA—*The Pareira Brava, or Velvet Leaf.—Sex. syst. Diœcia. Monadelphia. Nat. ord. Menispermaceæ.* HAB.—West Indies. PART USED.—The root, which occurs in more or less cylindrical pieces, some of which are as thick as a child's arm; externally they are covered by a dark brown rind. COMPOSITION.—The most important constituents are *fecula, supermalate of lime, nitrate of potash,* and some *ammoniacal* and *mineral salts*. It is also said to contain a vegetable alkali, called *Cissampelin*. EFFECTS.—Pareira acts as a diuretic and tonic, and appears to exert some specific influence over the mucous membrane of the urinary organs. USES.—It is chiefly used in discharges from the urino-genital mucous membrane, as gonorrhœa, leucorrhœa, and chronic inflammation of the bladder. It may be given in the form of *infusion* or *extract*.

CITRUS LIMONUM—*The Lemon Tree.—Sex. syst. Polyadelphia. Polyandria. Nat. ord. Aurantiaceæ.* HAB.—A native of Asia, cultivated in the south of Europe. PARTS USED.—The rind and the juice. COMPOSITION.—The *peel* contains *volatile oil* and a *bitter extractive principle*. The *juice* contains *citric* and *malic acid*. EFFECTS AND USES.—Lemon-*peel* is an aromatic stomachic and tonic, and as such is often added to other tonics, as in the compound infusion of gentian. Lemon-*juice* furnishes an agreeable and refreshing beverege, and is refrigerant and antiscorbutic. It is used in the preparation of refrigerant drinks, in the formation of the effervescing draught, as an antiscorbutic, as an antidote in cases of poisoning by the alkalies or their carbonates, and for the preparation of citric acid.—Vide *Acidum Citricum*.

CITRUS VULGARIS—*The Bitter Orange-tree.—Sex. syst. Polyadelphia. Polyandria. Nat. ord. Aurantiaceæ.* HAB.—Asia; cultivated in Europe.—PARTS USED.—The rind and the juice. COMPOSITION.—The composition of orange peel and juice is analogous to that of the same parts of the lemon. The juice of the orange contains sugar, and has less acid than that of the lemon. EFFECTS AND USES.—Much the same as those of the lemon; the orange-juice containing less acid is not adapted for forming the effervescing draught.

COCCULUS PALMATUS—*The Calumba Plant.—Sex. syst. Diœcia. Hexandria. Nat. ord. Menispermaceæ.* HAB.—Shores of Oibo and Mozambique. PARTS USED.—The roots. It is met with in circular or oval pieces of from half an inch to three inches diameter, and from one to three or four lines thick; it occurs also in cylindrical pieces of from one to two inches long. The epidermis is of a yellowish-grey or brownish colour. COMPOSITION.—It contains a *volatile odorous principle*, a *bitter principle* (*Calumbin*), *gum*, and about one-third by weight of *starch*. EFFECTS AND USES.—Calumba is a mucilaginous tonic, without being a stimulant. It may be given as a tonic in the early stage of convalescence from febrile and inflammatory diseases, before other tonics, which are also stimulants, are admissible. It is also useful in dyspepsia, and to allay vomiting when not dependent on inflammation of the stomach. DOSE.—The powder may be given in doses of from grs. x. to ʒ fs.; the *infusion* from f. ℥ j. to f. ℥ ij.; the *tincture* from f. ʒ j. to f. ʒ ij.

COCCUS CACTI—*The Cochineal Insect.—Cl. Insecta. Ord. Hemiptera.* HAB.—Mexico. The insects feed on the *nopal plant*. They are domesticated and reared with the greatest care. They are collected by brushing them off with a squirrel's tail. They are killed by immersion in hot water, and are subsequently dried in the sun or by the heat of a stove. Cochineal consists of the dried female insects, which are about one or two lines long, and of an irregular figure. They are inodorous, have a bitterish taste, tinge the saliva violet-red, and yield a dark red powder. COMPOSITION.—A brilliant purplish-red substance called *cochinellin*, or *carmine*, *peculiar animal matter*, *fatty matter*, and *salts*. USES.—The only use of cochineal is as a colouring matter. In the arts it is much used for dying scarlet and crimson, and in the manufacture of *carmine* and *lake*.

COCHLEARIA ARMORACIA—*The Horse-Radish.—Sex. syst. Tetradynamia. Siliculosa. Nat. ord. Cruciferæ.* HAB.—Indigenous. PARTS USED.—The root. COMPOSITION.—The properties of horse-radish depend on the presence of an *acrid volatile oil*. EFFECTS.—Horse-radish is a pungent acrid stimulant; applied to the skin it produces vesication; taken internally it promotes the secretion of urine and of perspiration; in large doses it is emetic. USES.—Chewed, it forms a good masticatory; an infusion may be used to excite vomiting in cases of narcotic poisoning. As a stimulant, diaphoretic, and diuretic, it has been used in palsy, chronic rheumatism, and dropsy. DOSE.—ʒ fs. or more.

COLCHICUM AUTUMNALE—*The Meadow-Saffron.—Sex. syst. Hexandria. Trigynia. Nat. ord. Melanthaceæ.* HAB.—Indigenous. PARTS USED.—The *cormus* and the *seeds*. The *cormus* should be gathered about the months of July and August, that is, between

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Materia Medica.

the withering of the leaves and the sprouting forth of the flower. At this period the new cormus is fully developed, and has not exhausted itself by the production of the flower. The *seeds* should be gathered when fully ripe. DESCRIPTION.—The *cormus* is about the size of a chestnut, and somewhat resembles in external appearance the cormus of the common tulip. It is rounded on one side, flattened on the other, where is perceived the fibrous germ of a new cormus, which, if allowed to grow, shoots up and bears the flower, while the old cormus wastes, becomes insipid, and inert. It is covered by two coats, an inner reddish-yellow, and an external brown one. Internally the cormus is white, fleshy, and has an acrid bitter taste. Before drying the cormus, it should be cut transversely in thin slices, the dry coats being previously removed. The seeds are about the size of those of white mustard, without odour, and having a bitter acrid taste. COMPOSITION.—Colchicum cormus, in addition to the ordinary constituents of vegetable substances, contains *veratria*, and, according to Geiger and Hesse, a peculiar principle called *colchicina*, which is a powerful poison. EFFECTS.—In small doses colchicum (the seeds or cormus) promotes the action of the secreting organs, especially of the intestines: in some cases the secretions of the skin and kidneys are considerably increased: it probably increases the biliary secretion. In larger doses it produces nausea, vomiting and purging, reduction of the frequency and force of the pulse, and, in some cases, faintness and extreme depression. Under some circumstances colchicum acts as an anodyne. In excessive doses it is a powerful irritant poison. USES.—Colchicum is chiefly celebrated for its efficacy in alleviating the gouty paroxysm; it relieves the pain and cuts short the attack. Its *modus medendi* is not satisfactorily ascertained: some consider it a specific, whilst others assert that it acts by the purging and the depression of the heart's action which it induces. In *rheumatism* colchicum is much less efficacious. DOSE.—The powder of the cormus and the seeds may be given in doses of from grs. ij. to grs. viij. There are various preparations in the Pharmacopœia: *Tinctura (Seminum) Colchici*, dose from f. ℨ fs. to f. ℨ j. *Vinum (Cormi) Colchici*, dose ♏x. to f. ℨ fs.; *Acetum (Cormi) Colchici*, dose ♏x. to f. ℨ j.; *Extractum (Cormi) Colchici Aceticum*, dose gr. i. to gr. iij.; *Extractum Colchici Cormi*, dose, gr. i. ANTIDOTES.—Promote vomiting by the use of tepid demulcent drinks, and counteract the depressing effects by the exhibition of stimulants.

COLOCYNTHIS.—Vide *Cucumis Colocynthis*.

CONIUM MACULATUM—*The Spotted Hemlock.—Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* HAB.—Indigenous. PARTS USED.—The *leaves*. The conium maculatum may be distinguished from the other umbelliferæ by attention to the following characters:—The large, round, smooth, spotted *stem*; the smooth, dark, and shining green colour of the lower *leaves*; the *general involucre* of from three to seven leaflets; the *partial involucre* of three leaflets; the fruit with undulated crenated ridges. The whole herb, when bruised, has a disagreeable odour, compared by some to that of mice, by others to that of fresh cantharides, or of cats' urine. COMPOSITION.—The most important constituents are a *volatile odorous matter* and *conia*. Conia exists in hemlock in combination with an acid. It is an oily looking transparent liquid, having the odour of hemlock, and an acrid taste; it is sparingly soluble in water, but entirely soluble in alcohol and ether; it combines with acids and forms salts. EFFECTS.—In small doses hemlock is considered to have an alterative effect, and has been supposed to have the power of arresting the growth of tumors. In large doses it acts as a narcotic poison; in some cases the leading symptom has been coma, in others convulsions, and in others delirium. *Conia* is a most virulent poison. Dr. Christison has recorded some experiments made on animals. One drop placed in the eye of a rabbit killed it in nine minutes. It acts locally as an irritant, but this effect is soon overwhelmed by the remote action which follows. This consists in a swiftly-spreading palsy of the muscles, affecting first those of voluntary motion, then the respiratory muscles of the chest and abdomen, lastly the diaphragm, and thus ending in death by asphyxia. USES.—The hemlock has been used with considerable benefit in cases of cancer, scrofula, and chronic skin diseases. In most of these cases it relieves pain, although it may not have the effect of removing the disease entirely. DOSE.—The powder may be given in doses of three or four grains: *Tinctura Conii*, dose f. ℨ fs. to f. ℨ j.; *Extractum Conii*, dose, grs. ij. or grs. iij. A poultice of hemlock is sometimes applied to painful sores. ANTIDOTES.—Evacuate the stomach as soon as possible; the subsequent treatment must depend on the symptoms. Artificial respiration should not be omitted in extreme cases.

CONVOLVULUS SCAMMONIA.—*The Scammony.—Sex. syst. Pentandria. Monogynia. Nat. ord. Convolvulaceæ.* HAB.—Greece and the Levant. PART USED.—The gum-resin. PREPARATION.—The earth is cleared from the upper part of the root, the top is cut off obliquely, the milky juice exudes, and is collected in a shell; it soon becomes hard, and is the genuine scammony. ADULTERATION.—It sometimes contains chalk and starch; the first is detected by adding an acid, the second by iodine. COMPOSITION.—Scammony contains about 80 per cent. of *resin*, with some gum, extractive, &c. EFFECTS AND USES.—Scammony is a powerful drastic purgative, being more violent in its action than jalap, but less so than gamboge. It is well adapted for torpid conditions of the intestines. It is an useful and safe purgative for children in cases of worms, &c. DOSE.—For an adult from grs. v. to grs. xv.

CONTRAJERVA RADIX.—Vide *Dorstenia Contrajerva*.

COPAIFERA—*Several species yielding Copaiba.—Sex. syst. Decandria. Monogynia. Nat. ord. Leguminosæ.* HAB.—South America and West Indies. PART USED.—The balsam, which is obtained by making incisions into the stems of the trees. COMPOSITION.—*Volatile oil* and *resin*. EFFECTS AND USES.—Copaiba is stimulant, diuretic, and gently purgative; it acts on the mucous membrane of the lungs as an expectorant; it also passes off by the skin, as is shown by the eruption which occasionally follows its internal exhibition. In large doses it produces vomiting. It is chiefly used in gleet and gonorrhœa, also in leucorrhœa, chronic inflammation of the bladder, and in chronic pulmonary catarrh. DOSE.—♏x. to f. ℨ j.

CORIANDRUM SATIVUM.—*The Coriander.—Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* HAB.—Indigenous. PART USED.—The fruit, which is globular, and about the size of white pepper. COMPOSITION.—It contains much volatile oil. EFFECTS AND USES.—Aromatic, stimulant, and carminative. It is used only as an adjuvant or corrigent.



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Cornu.—Vide *Cervus Elaphus*.

Creasoton—*Creasote*—prepared from the oil of wood tar. Properties. — Creasote is a colourless transparent liquid, having an oleaginous consistence; its sp. gr. is 1·037. It is combustible, being a compound of carbon, hydrogen, and oxygen. Effects.—Its local effects are those of an irritant and caustic. Internally it is stimulant, and in large doses produces nausea, vertigo, and headache; it sometimes acts as a diuretic. Uses.—It is much used for the relief of sympathetic vomiting, unaccompanied by gastric inflammation. It has been used in diabetes. In the form of ointment it is a useful remedy in some cutaneous diseases. It is sometimes dropped into a carious tooth for the relief of toothache. Dose.—One or two drops in mucilage.

Creta.—Vide *Calx*.

Crocus Sativus—*The Saffron Crocus.—Sex. syst. Triandria. Monogynia. Nat. ord. Iridaceæ.* Hab.—A native of Asia Minor, naturalized in Europe. Parts used.—The *styles and stigmata*. Composition.—Its most abundant and important constituent is a colouring principle called *polychroite*. Effects and Uses.—Saffron was formerly considered as a cordial, narcotic, and emmenagogue; but modern experience has proved that it possesses no such properties. It is used chiefly as a flavouring and colouring ingredient.

Croton Eleuteria—*The Cascarilla.—Sex. syst. Monœcia. Monadelphia. Nat. ord. Euphorbiaceæ.* Hab.—The Bahama Islands, Jamaica. Part used.—The bark. It exists in the form of quills, from one to four inches long, the fragments being thin and curved both longitudinally and transversely, the quills vary in size from that of a writing pen to that of the little finger. The taste is warm and bitter, the odour peculiar but agreeable. Composition.—Its aromatic and medicinal properties depend on the presence of *volatile oil, resin*, and *extractive*. Effects and Uses.—Cascarilla is an aromatic bitter tonic, and as such is useful in many forms of dyspepsia, and in other cases where tonics are indicated. The *infusion* is given in doses of f. ℥ j. or f. ℥ ij., the *tincture* of f. ʒ j. or f. ʒ ij.

Croton Tiglium—*The Purging Croton.—Sex. syst. Monœcia. Monadelphia. Nat. ord. Euphorbiaceæ.* Hab.—India, Indian Archipelago, and Ceylon. Part used.—The oil expressed from the seeds. The oil is of a yellowish-brown colour, and has an unpleasant odour and an acrid taste. It reddens litmus, and is soluble in alcohol. Effects.—Rubbed on the skin the oil produces rubefaction, and a pustular or vesicular eruption. Taken internally it acts as a drastic purgative, giving rise to watery stools, and frequently increasing the urinary secretion. Its operation is very speedy. In large doses it acts as an irritant poison. Uses.—The speedy action of croton oil, and the smallness of the dose, render it a most valuable cathartic in cases of coma, trismus, and obstinate constipation. It is sometimes applied to the skin as a counter-irritant. Dose.—From ♏j. to ♏iij.

Cubeba.—Vide *Piper Cubeba*.

Cucumis Colocynthis—*The Bitter Cucumber, or Colocynth.—Sex. syst. Monœcia. Syngenesia. Nat. ord. Cucurbitaceæ.* Hab.—Japan, India, the Cape, &c., cultivated in Spain. Part used.—The pulp of the fruit. Composition.—The active principle of colocynth is very bitter, and has received the name of *colocynthin*. Effects.—In moderate doses colocynth is a safe and useful purgative; it acts by accelerating the vermicular movements of the intestines, as well as by increasing the secretions. It has an especial action on the *large* intestines. In full doses it acts as a drastic hydragogue cathartic; in excessive doses it is an irritant poison. Uses.—It is used in habitual and obstinate constipation, in diseases of the brain, in dropsy, &c. Dose.—The powder may be given in doses of from grs. ij. to grs. x.; the most common mode of administering it is in the form of the *compound extract*, in which the colocynth is combined with aloes, scammony, cardamoms, and soap. The dose of this is from gr. v. to ℈j.

Cupri Sulphas—*Sulphate of Copper.* Preparation.—It may be obtained by evaporating the water found in copper mines; it is also produced by roasting the native sulphuret of copper, lixiviating the residuum to dissolve the sulphate, and evaporating so as to obtain crystals. Properties.—This salt is in blue crystals; it has a styptic metallic taste, and re-acts on litmus as an acid. Characteristics.—That this salt is a sulphate may be known by the precipitate afforded with chloride of barium, which is insoluble in acids or alkalies; that the base is copper may be ascertained by plunging a polished iron plate into the solution, when it becomes coated with metallic copper. Composition.—One eq. oxide of copper, one eq. sulphuric acid, and five eqs water. Effects.—In small doses sulphate of copper is astringent; in larger doses it acts speedily as an emetic, without producing disorder of the general system; in excessive doses it is an irritant poison. Uses.—As an astringent in diarrhœa, as a tonic in some nervous diseases, and as an emetic in cases of narcotic poisoning; it is also used *locally* as an astringent. Dose.—As an emetic, from grs. iij. to grs. xv.; as an astringent, from gr. ¼ to grs. ij. Antidotes.—Albumen or iron filings.

Cupri Ammonio-Sulphas—*Ammonio-sulphate of Copper.* Preparation.—An ounce of sulphate of copper is rubbed with an ounce and a half of sesquicarbonate of ammonia until carbonic acid ceases to escape. Composition.—It is composed of carbonate of copper and sulphate of ammonia, with the excess of sesqui-carbonate of ammonia employed. Effects and Uses.—Similar to those of the sulphate of copper, than which it is somewhat more stimulant. Dose, from gr. ſs. to gr. v.

Cupri Diacetas—*Diacetate of Copper—Verdigris*—prepared by exposing plates of copper to acetic acid. The acetate which forms is scraped off and collected. Properties.—It occurs in masses or in powder. It is of a bluish-green colour, having an astringent metallic taste, and an odour something like that of acetic acid. Characteristics.—When digested with strong sulphuric acid, it evolves acetic acid, which is distinguished by its odour. Composition.—Two eqs. oxide of copper, one eq. acetic acid, six eqs. water. Effects and Uses.—Its effects are much the same as those of the sulphate, but on account of the uncertainty of its action it is never given internally. Antidotes.—The same as for the sulphate.

Cusparia.—Vide *Galipea Cusparia*.

Cytisus Scoparius—*Common Broom.—Sex. syst. Diadelphia. Decandria. Nat. ord. Leguminosæ.* Hab.—Indigenous. Parts used.—The tops. Composition.—Broom tops contain *volatile oil, tannin*, &c. Effects and Uses.—In small doses they are diuretic, and, in

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large doses, emetic and purgative. They are used in dropsies, usually in the form of *infusion* or *decoction*.

DAPHNE MEZEREUM—*The Common Mezereon.*—*Sex. syst. Octandria. Monogynia. Nat. ord. Thymelaceæ.* HAB.—Indigenous. PART USED.—The bark of the root. COMPOSITION.—The active principle of mezereon is an *acrid resin*. EFFECTS.—The local effect is that of an acrid stimulant. Taken internally it is a stimulating diaphoretic, and in some cases a diuretic. USES.—It is seldom given alone; but generally combined with sarsaparilla in syphilitic and rheumatic affections. It is sometimes used as a masticatory.

DATURA STRAMONIUM—*The Thorn Apple.*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Solanaceæ.* HAB.—Indigenous. PARTS USED.—The leaves and seeds. COMPOSITION.—The medicinal properties of stramonium depend on the presence of an alkali called *daturia*. EFFECTS AND USES.—Its effects closely resemble those produced by belladonna. (Vide Atropa Belladonna). It differs from belladonna in being somewhat more acrid. It is used in nearly the same cases as those in which belladonna is indicated. In some cases of spasmodic asthma, smoking the leaves gives temporary relief. DOSE.—The dose of the powdered leaves is gr. j.; of the seeds, gr. fs.; of the *extract*, gr. ¼. gradually increased. ANTIDOTES.—The same as for belladonna.

DELPHINIUM STAPHISAGRIA—*Stavesacre.*—*Sex. syst. Polyandria. Trigynia. Nat. ord. Ranunculaceæ.* HAB.—South of Europe, Levant, and the Canaries. PARTS USED.—The seeds, which are irregularly triangular, blackish-brown, and wrinkled. COMPOSITION.—The seeds contain an alkali called *delphinia*, and a vegetable acid. EFFECTS.—The seeds are emetic and cathartic, but their operation is so violent that they are never used internally. USES.—They are chiefly employed in powder, mixed with hair-powder, for destroying pediculi of the head.

DIGITALIS PURPUREA—*The Purple Fox-Glove.*—*Sex. syst. Didynamia. Angiospermia. Nat. ord. Scrophulariaceæ.* HAB.—Indigenous. PARTS USED.—The leaves and seeds. The leaves should be gathered just before, or during the period of inflorescence. They should be dried in baskets in a drying stove. COMPOSITION.—The analyses of digitalis are unsatisfactory; but its active properties are thought to depend on a crystalline substance, called *Digitalina*. EFFECTS.—In repeated small doses, fox-glove produces disorder of the stomach, nausea, or vomiting. It affects the pulse; in some cases increasing its frequency, more commonly diminishing it, and frequently rendering it irregular and intermittent. It acts on the kidneys as a diuretic, and in some rare cases produces salivation. In larger doses it produces vomiting, slow and irregular pulse, coldness of the extremities, syncope, or a tendency to it, giddiness, and confusion of vision. In excessive doses these symptoms are more severe, and often terminate fatally. An important fact is, that during the continued use of small doses a *cumulative* effect is sometimes observed; and dangerous symptoms may suddenly appear, in some cases terminating in death. USES.—Digitalis is used as a diuretic in dropsy; as a sedative in some cases of fever and inflammation, in hæmorrhages, in diseases of the heart and great vessels, and in phthisis. DOSE.—The dose of the *powder* is from gr. fs. to gr. ifs; of the *infusion*, from f. ʒ ij. to f. ℥ j.; of the *tincture*, from ♏ x. to ♏ xl.; and of the *extract*, gr. j. ANTIDOTES.—Remove the poison from the stomach as speedily as possible. Give brandy and ammonia to counteract the depressing action of the poison on the circulation; and keep the patient in a recumbent posture to guard against syncope.

DIOSMA CRENATA—*The Buchu.*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Rutaceæ.* HAB.—Cape of Good Hope. PARTS USED.—The leaves. COMPOSITION.—*Volatile oil, bitter extractive*, &c. EFFECTS AND USES.—Aromatic stimulant and diuretic. Chiefly used in chronic inflammation and catarrh of the bladder. DOSE.—In powder ℈j. or ʒ fs. It is usually taken in the form of *infusion* or *tincture*.

DOREMA AMMONIACUM—*The Ammoniacum Plant.*—*Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* HAB.—Persia. PART USED.—The juice which exudes from punctures in the stems. It soon concretes, and is found in commerce either in distinct tears, or in masses composed of agglutinated tears. COMPOSITION.—*Resin, gum*, and *volatile oil*. EFFECTS.—Similar to, but less powerful than, those produced by assafœtida. USES.—It is chiefly used as an expectorant in chronic pulmonary complaints. DOSE, grs. x. to ʒ fs.

DORSTENIA CONTRAJERVA—*The Contrajerva.*—*Sex. syst. Petandria. Monogynia. Nat. ord. Urticaceæ.*—HAB.—South America, and the West Indies. PART USED.—The root. COMPOSITION.—It contains *volatile oil, bitter extractive*, and *resin* EFFECTS AND USES.—Stimulant, tonic, and diaphoretic. It is occasionally used in low fevers. DOSE, of the powdered root, ℈j. or ʒ fs.

ELETTARIA CARDAMOMUM—*The Cardamom.*—*Sex. syst. Monandria. Monogynia. Nat. ord. Zingiberaceæ.* HAB.—East Indies. PARTS USED.—The seeds. COMPOSITION.—The seeds contain a large proportion of *volatile oil* and some *fixed oil*. EFFECTS AND USES.—An agreeable aromatic and carminative, and as such frequently administered with other remedies. In the Pharmacopœia there is a *simple tincture* and a *compound tincture of cardamoms*. The latter contains, in addition to cardamoms, caraway, cochineal, cinnamon, and raisins. The dose of these is f. ʒ j. or f. ʒ ij.

ERYTHRÆA CENTAURIUM—*Common Centaury.*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Gentianaceæ.* HAB.—Indigenous. PARTS USED.—The herb or tops. They are collected when in flower. COMPOSITION.—It contains a *bitter extractive matter*. EFFECTS AND USES.—Similar to those of gentian. DOSE, in powder, ℈j. to ʒ j.

ETHER SULPHURICUS—*Sulphuric Ether.* PREPARATION.—The following are the directions in the *London Pharmacopœia*:—"Take of rectified spirit three pounds, sulphuric acid two pounds, carbonate of potash, previously ignited, an ounce; pour two pounds of the spirit into a glass retort, add the acid to it, and mix. Afterwards place it on sand, and raise the heat so that the liquor may quickly boil, and the ether pass into a receiving vessel made cool with ice or water. Let the liquor distil until some heavier portion begins to pass over. To the liquor which remains in the retort, after the heat has subsided, pour the remainder of the spirit, that ether may distil in the same manner. Mix the distilled liquors, then pour off the supernatant portion, and add to it the carbonate of potash, shaking them frequently during an hour. Lastly, let the ether distil from a large retort, and be kept in a stoppered vessel." THEORY OF ETHERIFICATION.—The composition of alcohol is $O_2\,C_4\,H_6$. When sulphuric acid is added to

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alcohol, 2 eqs. of the acid combine with 1 eq. of alcohol to form an acid called the *sulphovinic acid*. By heat, this acid is decomposed, the 2 eqs. of sulphuric acid remain in the retort, with 1 eq. of water, abstracted from the alcohol; and ether, thus formed by the abstraction of 1 eq. of water from 1 eq. of alcohol, distils over. The composition of ether then is $O\ C_4\ H_5$; and it may be considered as the oxide of a hypothetical *radical* ethule ($C_4\ H_5$). According to this view, then, ether is an oxide of ethule; alcohol a hydrated oxide of ethule; and sulphovinic acid a hydrated bisulphate of the oxide of ethule. The sulphuric acid undergoes no other change than that of becoming diluted with the water which it abstracts from the alcohol. The rectification of ether is effected by the addition of carbonate of potash, and redistillation. The salt abstracts any water and acid which may be combined with the ether, and the latter passes over pure. PROPERTIES.—At ordinary temperatures ether is a colourless limpid liquid, having a peculiar penetrating fragrant odour, and a hot and pungent taste. The ether of the shops varies in its sp. gr. from ·733 to ·765. It is very volatile. The sp. gr. of its vapour compared with air as unity is 2·586. Ether is very combustible: it is sparingly soluble in water, but soluble in alcohol in all proportions. EFFECTS.—The operation of ether is analogous to that of alcohol, but is more rapid and transient. In moderate doses it allays spasm and relieves flatulence. Its first effects on the cerebral functions are those of an excitant, but the subsequent ones are those of a depressing agent. In larger doses it produces intoxication, like that caused by alcohol. In excessive doses, it occasions nausea, giddiness, and stupefaction. USES.—Ether is a valuable remedy in cases of spasm and cramp of the stomach, and in many other painful and spasmodic affections. As a stimulant in syncope, in the low stage of fever, and in various other diseases attended with great prostration. It is sometimes used as an external application for the cold produced during its evaporation. DOSE, from f. ʒ fs. to f. ʒ ij. ANTIDOTES.—Evacuate the stomach, cold affusion to the head and chest, the internal use of ammonia, and if necessary artificial respiration.

EUPHORBIA OFFICINARUM—*The Officinal Euphorbium.—Sex. syst. Dodecandria. Trigynia. Nat. ord. Euphorbiaceæ.* HAB.—Africa. PART USED.—The concrete milky juice, which exudes when incisions are made into the plant. COMPOSITION.—The active ingredient is an *acrid resin*. EFFECTS.—Euphorbium is a violent acrid. Applied to the skin it produces itching, pain, and inflammation, succeeded by vesication. When swallowed it produces vomiting and purging, and, in large doses, is an irritant poison. When the vapour is inhaled it gives rise to sneezing and irritation about the eyes and nose. USES.—It was formerly used as an emetic and purgative; but the violence and danger of its operation have led to its disuse. Mixed with other substances, it is occasionally used as a counter-irritant.

FERRUM—*Iron*. EXTRACTION.—In Sweden, iron is extracted from magnetic iron ore; in England, principally from clay iron ore (carbonate of iron). CHARACTERISTICS.—Iron dissolves in dilute sulphuric acid, with the evolution of hydrogen gas. The solution contains the proto-sulphate of iron. On the addition of potash or soda a greenish-white precipitate of the hydrated protoxide occurs: by exposure to the air this precipitate attracts oxygen, and is converted into the red or sesqui-oxide. By boiling the solution with nitric acid, we obtain the persulphate of iron, known by the blue colour produced by the ferro-cyanide of potassium, and the black by the infusion of galls. EFFECTS AND USES.—In the *metallic state* iron is inert, but it readily oxidizes in the alimentary canal, and thus acquires medicinal power. The ferruginous compounds generally act as slight *local irritants*, especially the sulphate and the chloride. They act as astringents, and check secretion and exhalation from the parts with which they come in contact. In large doses they produce a sensation of weight and pain in the præcordia, and sometimes excite vomiting and purging. The constitutional effects of the ferruginous compounds are best seen in *anæmic* states of the system, especially in chlorotic girls, in whom the skin and lips are pale, and the cellular tissue is œdematous from a defect in the quantity and quality of the blood. In such a condition of the system, the use of iron is followed by a return of the natural colour, an increase of strength, an improvement of the appetite, and the restoration of the uterine functions, if these have been suspended, as usually happens in such cases. Iron is supposed to act in these cases by increasing the colouring matter of the blood, which naturally contains a considerable proportion of this metal. Iron has no specific emmenagogue effect; but in one case it promotes the uterine discharge, and in another checks it, according as it has been previously deficient or excessive.

FERRI SULPHAS—*Sulphate of Iron*. PREPARATION.—Dissolve clean metallic iron in dilute sulphuric acid, and evaporate that crystals may be formed. In this process the sulphuric acid combines with the protoxide of iron, formed by the decomposition of water, the corresponding hydrogen escaping. PROPERTIES.—The crystals are of a pale-green colour: by exposure to the air oxygen is absorbed, and they acquire a yellowish-brown colour (sulphate of the sesqui-oxide of iron). They are soluble in water. EFFECTS AND USES.—Those of the ferruginous preparations generally. It is to be preferred where there is great relaxation of the solids with immoderate discharges. DOSE, from gr. j. to gr. v. in the form of pill. A most valuable combination in chlorosis consists of five grains each of sulphate of iron and extract of gentian, to be made into two pills, and taken three times a-day.

FERRI SESQUI-OXYDUM—*Sesqui-oxide of Iron*. PREPARATION.—Dissolve sulphate of iron in water, and add to it a solution of carbonate of soda; let the powder subside. Lastly, the supernatant liquor being poured off, wash what is precipitated in water and dry it. The precipitate is composed of carbonate of the protoxide of iron, but by exposure to the air during the washing and drying the carbonic acid escapes, and more oxygen combining with the protoxide converts it into a sesqui-oxide. PROPERTIES.—It is a brownish-red powder, inodorous, and insoluble in water. EFFECTS AND USES.—Those of the ferruginous compounds in general. It is but slightly astringent. It has been much given in neuralgia. DOSE, from grs. x. to ʒ j.

FERRI POTASSIO-TARTRAS—*Tartarized Iron*. PREPARATION.—Boil together powdered bitartrate of potash, water, and moist hydrated sesqui-oxide of iron. Filter and evaporate to dryness. COMPOSITION.—One eq. of tartrate of sesqui-oxide of iron, and one eq. of tartrate of potash. PROPERTIES.—It is an olive-brown inodorous powder, with a styptic inky taste. It dissolves in about four times its weight of water. EFFECTS AND USES.—

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These agree with those of the other compounds of iron. It it is but slightly astringent. Dose, grs. x. to ʒ fs.

Ferri Iodidum—*Iodide of Iron.* Preparation.—Mix iodine with water, and add iron filings. Heat them in a sand-bath, and when it has acquired a greenish colour, pour off the liquor, and evaporate that the salt may be dried. Properties.—It is an opaque iron-grey crystalline mass, with a faint metallic lustre, and a styptic taste. It is soluble in both water and alcohol. It readily attracts oxygen from the air, and forms sesqui-oxide and sesqui-iodide of iron. Effects and Uses.—This compound is supposed to combine the effects of iron and iodine, and is much used in scrofula and in some cases of secondary syphilis. Dose, grs. iij. to grs. x.

Ferri Sesqui-chloridi Tinctura—*Tincture of Sesqui-chloride of Iron.* Preparation.—Pour a pint of hydrochloric acid upon six ounces of sesqui-oxide of iron in a glass vessel, and digest for three days, frequently shaking; then add three pints of rectified spirit and strain. Properties.—This tincture has a reddish-brown colour, a sour styptic taste, and an odour of hydrochloric ether. It re-acts on vegetable colours as an acid. Composition.—It consists of rectified spirit, a small portion of hydrochloric ether, hydrochloric acid, and sesqui-chloride of iron. Effects and Uses.—This preparation is a powerful astringent and styptic, and, in large doses, irritant. Its constitutional effects are the same as those produced by other ferruginous preparations, and, like them, it colours the fæces black: it is besides a powerful diuretic, and is useful in arresting hæmorrhage from the bladder or kidneys. As a *styptic* it is sometimes used to arrest bleeding from small vessels. Dose, from ♏ x. to ʒ j. Antidotes.—The same as for the mineral acids.

Ferula Assafœtida—*The Assafœtida.—Sex. syst. Pentandria. Digynia. Nat. ord. Umbelliferæ.* Hab.—Persia. Part used.—The concrete juice, which is obtained by making incisions into the upper part of the root. It exists in tears and in lumps. It is fusible and inflammable. Its taste is acrid and bitter, and its odour alliaceous. Composition.—*Resin*, *gum*, and *volatile oil* are the chief constituents. Effects and Uses.—Assafœtida is a stimulant, expectorant, and antispasmodic. It is useful in spasmodic and convulsive hysterical affections, in flatulent colic, and in chronic catarrh. Dose, grs. v. to ʒ j. It may be given in the form of pill, or made into an emulsion with water, or in the form of *tincture*.

Ferula? *An uncertain species yielding Sagapenum.*—Sagapenum exists in the form of tears, or in masses. It has an aromatic and agreeable odour similar to, though more pleasant than, that of galbanum. Composition.—*Gum*, *resin*, and *volatile oil*. Effects and Uses.—The same as those of assafœtida. Dose, gr. v. to ʒ fs.

Galbanum Officinale—*The Officinal Galbanum.*—The plant yielding this gum is not known, nor is the precise country in which it is produced. Galbanum occurs in the form of tears and of lumps. It has a peculiar balsamic odour, and a hot, acrid, and bitter taste. Composition.—*Volatile oil*, *gum*, and *resin*. Effects and Uses.—The same as those of assafœtida. Dose, grs. x. to ʒ fs., in the form of pill or emulsion.

Galipea Cusparia and G. Officinalis—*The Cusparia.—Sex. syst. Diandria. Monogynia. Nat. ord. Rutaceæ.* Hab.—South America. Part used.—The bark. It occurs in flat pieces and quills, of various sizes, covered with a yellowish-grey epidermis. The internal surface is brownish, and easily separable into laminæ. Composition.—It contains *volatile oil*, *bitter extractive*, and *resin*. Effects and Uses.—Cusparia or Angustura bark is a powerful aromatic and stimulant tonic. It is not astringent; but in full doses produces nausea and purging. It may be used in all cases for which cinchona is administered, although it is not equally efficacious as an antiperiodic remedy. Dose, in powder, from grs. x. to ʒ fs. The *infusion* is the most eligible form.

Gallæ.—Vida *Quercus*.

Gentiana Lutea—*Common or Yellow Gentian.—Sex. syst. Pentandria. Digynia. Nat. ord. Gentianaceæ.* Hab.—Alps of Austria and Switzerland. Part used.—The root. Composition.—A *volatile odorous principle*, *gentisin*, *bitter principle*, *pectin*, and *sugar*. Effects and Uses.—Gentian is a simple bitter tonic, without being astringent or very stimulant. In large doses it relaxes the bowels. It is a valuable remedy in dyspepsia, and in many other diseases marked by weakness and debility, but unattended by fever or irritation of the stomach and intestines. It is usually given in the form of *infusion*, *tincture*, or *extract*.

Granati Cortex.—Vide *Punica Granatum*.

Guaiacum Officinale—*The officinal Guaiacum.—Sex. syst. Decandria. Monogynia. Nat. ord. Zygophyllaceæ.* Hab.—St. Domingo and Jamaica. Parts used.—The wood and the resin. The resin is obtained by natural exudation from the stem; or by exudation from wounds artificially made in different parts of the tree; or by heating billets placed on the fire, with a hole burnt in the end of each, from which the melted resin exudes, and is collected. It is also obtained in small quantities by boiling the wood in water with common salt. The resin swims at the top, and may be skimmed off. Guaiacum occurs in tears and in masses. It has a greenish-brown colour, and a brilliant resinous fracture; it has a balsamic odour, and when chewed leaves a burning sensation in the throat. Composition of Guaiacum.—It is essentially a *peculiar resin*, mixed with some extractive and other impurities. Effects and Uses.—Guaiacum is an acrid stimulant, diaphoretic, expectorant, and alterative. In large doses it produces vomiting, purging, and headache. It is used in chronic rheumatism, in some forms of gout, in chronic skin diseases, and as a remedy for some forms of secondary syphilis. Dose, of powdered resin, grs. x. to ʒ fs. In the Pharmacopœia there is a *mixture*, a *tincture*, and a *compound tincture of guaiacum*.

Hæmatoxylon Campechianum—*The Logwood.—Sex. syst. Decandria. Monogynia. Nat. ord. Leguminosæ.* Hab.—Campeachy. Part used.—The wood. As imported it consists only of the heart-wood. The logs are externally of a dark colour; internally, red. Composition.—*Volatile oil*, *hæmatin*, *resin*, *tannin*, &c. Effects and Uses.—Logwood is a mild astringent, and as such is used in diarrhœa, dysentery, and hæmorrhages. It is used in the form of *decoction* or *extract*; the dose of the latter is from grs. x. to ʒ fs.

Hebradendron Cambogioides—*The Gamboge Hebradendron.—Sex. syst. Monœcia. Monadelphia. Nat. ord. Guttiferæ.* Hab.—Ceylon. This is the plant which yields Ceylon gamboge. The Siam gamboge is yielded by an unascertained species; probably a species of Hebradendron. Preparation.—Siam gamboge is obtained by breaking the leaves and small branches, when a milky juice exudes, and is collected on the leaves of the tree, or in cocoa-nut shells, and from thence is transferred into large flat earthen vessels, where it is allowed to harden, and is afterwards enve



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loped in leaves. The cylindrical or pipe variety receives its form by being run into the joints of the bamboo while it is in the liquid state. In Ceylon, gamboge is obtained by wounding the bark of the tree in various places. The juice which exudes hardens in the sun. The Siam gamboge only is met with in commerce. This occurs in two forms,—the *pipe* and the *cake* gamboge. Composition.—It contains *gambogic acid* and *gum*; the former of these is the active principle. Effects and Uses.—Gamboge is a powerful hydragogue cathartic. In excessive doses it acts as an acrid poison. It is used in obstinate constipation, in cerebral affections, in dropsies, and occasionally as an anthelmintic. Dose, from gr. j. to gr. vj. in the form of pill.

Helleborus Niger—*The Black Hellebore.—Sex. syst. Polyandria. Polygynia. Nat. ord. Ranunculaceæ.* Hab.—Middle and southern parts of Europe. Part used.—The root, which consists of two parts; the rhizome or root-stock, and the fibres arising from it. Composition.—Its activity depends on the presence of an *acrid oil*. Effects and Uses.—Black hellebore is a local irritant. Taken internally it is a violent purgative and emmenagogue; in large doses it produces vomiting, and symptoms of inflammation of the intestinal canal. It is but little employed; but it may be cautiously used in some affections of the nervous system, as in mania, as an emmenagogue, and in dropsy. Dose, of the powdered root, grs. iij. to ℈j. *Tinctura Hellebori.* (Hellebore bruised, ℥ v.; proof spirit, O ij Macerate for fourteen days, and strain). Dose, f. ʒ ß. to f. ʒ j.

Helonias Officinalis—*The Cebadilla.—Sex. syst. Hexandria. Trigynia. Nat ord. Melanthaceæ.* Hab. —Mexico. Parts used.—The seeds. They are two or three lines long, scimitar-shaped, dark brown. They have little odour, but a bitter, acrid, persistent taste. Composition.—The medical properties of the seeds depend on the presence of the alkali *veratria*. Effects. —Its action is similar to that of white hellebore, but more violent. Use.—It is introduced into the Pharmacopœia as the source from which veratria is obtained.

Humulus Lupulus—*The Hop Plant.—Sex. syst. Diœcia. Pentandria. Nat. ord. Urticaceæ.* Hab.— Indigenous. Parts used.—The strobiles or catkins. Composition.—*Volatile oil*, *resin*, and a *bitter principle* (*lupuline*). Effects and Uses.—The odorous emanations are said to possess narcotic properties; and a pillow of hops has been used in mania and other cases in which restlessness prevails. Internally hops produce the effects of an aromatic tonic, and they have perhaps *very slight* sedative and soporific properties. The chief consumption of hops is in the manufacture of beer. They may be given in the form of *powder*, *infusion*, *tincture*, or *extract*.

Hydrargyrum—*Quicksilver or Mercury.* Preparation.—It is obtained from native cinnabar (bisulphuret of mercury). The cinnabar is mixed with caustic lime, and distilled in iron retorts. The lime abstracts the sulphur, and the disengaged mercury distils over. Characteristics.—In its metallic state mercury is recognized by its liquidity, and by its volatility. The salts of mercury, when heated with potash or soda, are reduced, and globules of metallic mercury are obtained. Solutions of the salts placed in contact with a bright surface of copper, leave a silvery stain, which disappears when heated to redness. Solutions of the proto-salts of mercury yield with caustic potash or soda a grey or black precipitate, and with iodide of potassium a greenish or yellow precipitate. Solutions of the per-salts yield with potash or soda a yellow or reddish precipitate, and with iodide of potassium a scarlet one. Effects.—Metallic mercury, when swallowed, is inert, unless it becomes oxidized, as it may do in the alimentary canal. Applied externally, it has sometimes produced salivation. Mercurial vapours, when inhaled and applied to the surface of the body, produce most injurious effects. Thus gilders and men employed in quicksilver mines are subject to an affection called the *shaking palsy*. It commences with unsteadiness of the limbs, and frequently goes on to complete palsy of the whole body. Exposure to the vapour of mercury is sometimes followed by salivation and other constitutional effects. The *mercurial compounds* have the local action of irritants, and some of them act as energetic caustics. Internally, in small doses, the compounds of mercury are considered to have an *alterative* action. Moderate doses increase most of the secretions, especially those of the digestive organs. The alvine evacuations become more liquid, and contain a larger proportion of bile. The urine is slightly increased in quantity, and the cutaneous exhalation is augmented. If small doses are long continued, or larger doses are given, the most marked influence is exerted on the mouth and salivary glands. The gums become swollen and red; there is pain and swelling about the jaws, followed by a greatly increased flow of saliva. In some cases the inflammation of the parts about the mouth goes on to ulceration and sloughing; this may arise from the administration of large quantities, or from a peculiar susceptibility of the influence of small doses. When the system is under the influence of mercury, the patient complains of a coppery taste in the mouth, and the breath has a peculiar fœtid odour. Some bad effects occasionally follow the medicinal use of mercury: of these the most common are—excessive salivation, violent purging, ulceration, and sloughing of the mouth, and sometimes necrosis of the bones of the jaw. A cutaneous eruption is occasionally induced by the use of mercury; the most common form is the *eczema mercuriale*. In excessive doses, some of the mercurial compounds act as irritant poisons, and if the symptoms continue more than twenty-four hours, the above-mentioned constitutional effects usually make their appearance. Uses.—The mercurial compounds are used, in small doses, as alteratives in various chronic diseases In moderate doses as purgatives, usually combined with some vegetable purgative. The constitutional effects of mercury are induced in the treatment of inflammations, especially of those kinds of inflammation which are attended with an abundant effusion of coagulable lymph (the *adhesive inflammation*); since it is most satisfactorily ascertained that the condition which mercury induces is directly opposed to the adhesive inflammation. In certain forms of syphilis mercury is a most valuable remedy; the cases in which it is applicable can only be learnt by a careful study of the disease. Modern observation has sufficiently shown that mercury is by no means essential for the cure of syphilis.

The preparations of mercury are very numerous; we must content ourselves with a brief notice of the most important.

Hydrargyri Bichloridum—*Bichloride of Mercury.* Preparation.—Two pounds of mercury are boiled with three pounds of sulphuric acid, to dryness. We thus obtain a bi-persulphate of mercury; the dry salt is then mixed with a pound and a half of chloride of sodium, and sublimed. We thus obtain sulphate of soda and

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bichloride of mercury; the latter sublimes. PROPERTIES.—It is usually seen in a semi-transparent crystalline mass. The taste is acrid and coppery. It is soluble in about three times its weight of boiling and in about twenty times its weight of cold water. It is soluble in alcohol and in ether. CHARACTERISTICS.—Iodide of potassium gives, with a solution of bichloride, a scarlet precipitate of the biniodide of mercury; the colour disappears if there be an excess of either salt. This test is quite characteristic. COMPOSITION.—1 eq. of mercury, 2 eqs. of chlorine. EFFECTS.—In medicinal doses it produces the effects of the mercurial preparations generally. In somewhat larger doses it produces symptoms of chronic inflammation of the stomach and intestines. In excessive doses it is a most violent irritant poison, the symptoms being much the same as those produced by arsenic. USES.—Its chief use is as an alterative in chronic diseases. DOSE.—From gr. $\frac{1}{16}$th to gr. $\frac{1}{8}$th. ANTIDOTES.—The best antidote for this salt is *albumen*, with which it forms an insoluble compound. The white of one egg is sufficient to neutralize four grains of the poison.

HYDRARGYRI CHLORIDUM—*Chloride of Mercury (Calomel)*. PREPARATION.—Mercury and sulphuric acid are boiled together in the same manner as for the preparation of the bichloride. The bi-persulphate is then mixed with two pounds of metallic mercury, and subsequently with a pound and a half of chloride of sodium, and sublimed. We thus obtain sulphate of soda and a protochloride of mercury. PROPERTIES.—Calomel crystallizes in the form of the right square prism. It is white, volatile, insoluble in water and in alcohol. CHARACTERISTICS.—This is known to be the protochloride by its insolubility in water, and by the black precipitate of the protoxide which it gives with lime-water; while the supernatant liquor, on the addition of nitrate of silver, gives evidence of the presence of chlorine. COMPOSITION.—1 eq. of mercury, 1 eq. of chlorine. EFFECTS.—Those of the mercurial compounds generally. It is not caustic, nor is it very poisonous even when given in large doses. USES.—Calomel is the most used of any mercurial compound; it is given as an alterative, purgative, sialagogue, anthelmintic, and in large doses as a sedative in cholera. DOSE.—The ordinary doses are from gr. ſs. to grs. v. The celebrated PLUMMER'S pill is composed of *chloride of mercury*, ʒ ij., *oxysulphuret of antimony*, ʒ ij., *guaiacum resin* powdered, ʒ ſs. *treacle*, ʒ ij. It is much used as an alterative. Dose, grs. v. to grs. x.

HYDRARGYRUM CUM CRETA—*Mercury with Chalk*. PREPARATION.—It is prepared by rubbing three ounces of mercury with five ounces of chalk, until globules are no longer visible. PROPERTIES.—It is a greyish powder, which effervesces on the addition of acetic acid, yielding a solution of lime. COMPOSITION.—It consists of chalk, with metallic mercury, and a small portion of protoxide. EFFECTS AND USES.—It is valuable as a mild alterative and a purgative for infants. DOSE.—For adults, grs. v. to ℈ j.; for children, grs. ij. or grs. iij.

HYDRARGYRI PILULÆ—*Pills of Mercury—(Blue Pills)*. PREPARATION.—Rub two drachms of purified mercury with three drachms of confection of roses until globules are no longer visible, then add a drachm of powdered liquorice-root. EFFECTS AND USES.—It is much used as an alterative and purgative. Dose, grs. v.

HYDRARGYRI UNGUENTUM—*Ointment of Mercury*. PREPARATION.—It is prepared by rubbing two pounds of mercury with an ounce of suet and twenty-three ounces of lard until globules are no longer visible. EFFECTS AND USES.—When applied to the surface of the body it becomes absorbed, and produces the constitutional effects of mercury. It is used chiefly as a means of affecting the constitution, especially when from irritability of the digestive organs, or from some other cause, the internal use of mercury is not admissible. Half a drachm or a drachm may be rubbed on the skin night and morning.

HYDRARGYRI NITRICO OXYDUM—*Nitric oxide of Mercury*. PREPARATION.—Mercury is dissolved in nitric acid, and the solution evaporated to dryness; the residue is reduced to powder, and heated until red vapours cease to arise. PROPERTIES.—It occurs in bright red crystalline grains or scales. When quite free from nitrate of mercury it is insoluble in water. EFFECTS AND USES.—Its local action is that of an irritant. In the form of ointment it is a valuable stimulant, and is often applied to indolent ulcers and to some forms of cutaneous disease.

The above are the preparations of mercury in most frequent use. There are others of less importance, such as the following:—*Hydrargyri Iodidum; H. Biniodidum; H. Oxydum; H. Binoxydum; H. Bisulphuretum; H. Ammonio-Chloridum.*

HYOSCYAMUS NIGER—*The Henbane.—Sex. syst. Pentandria Monogynia. Nat. ord. Solanaceæ.* HAB.—Indigenous. PARTS USED.—The leaves and seeds. COMPOSITION.—The properties depend on a vegetable alkali, *hyoscyamia*. EFFECTS AND USES.—The effects of henbane very closely resemble those of belladonna and stramonium; it however differs from them in this, that large doses seldom produce symptoms of irritation of the intestinal canal. USES.—Hyoscyamus is used to alleviate pain, to remove spasm, and to promote sleep. For these purposes it is less to be relied on than opium; but it may be advantageously employed when opium is found to produce headache or other unpleasant symptoms. It does not, like opium, stimulate the vascular system, nor does it produce constipation. DOSE.—The powdered leaves may be given in doses of from grs. iij. to grs. x. The *extract* and *tincture* are the preparations most in use; the dose of the former is from gr. v. to ℈ j.; of the latter f. ʒ ſs. to f. ʒ ij. ANTIDOTES.—The same as for opium.

INULA HELENIUM—*Elecampane.—Sex. syst. Syngenesia. Polygamia. superflua. Nat. ord. Compositæ.* HAB.—Indigenous. PART USED.—The dried root. COMPOSITION.—*Volatile oil, elecampane camphor, resin, inulin*, and *bitter extractive*. EFFECTS AND USES.—It is an aromatic tonic, and is slightly diaphoretic, diuretic, and expectorant; it is seldom used. DOSE.—Of the powdered root, ℈ j. to ʒ ij.

IODINUM—*Iodine*. PREPARATION.—Iodine is obtained from the ashes of the *Fucoideæ* (a tribe of seaweeds); the ashes are called *kelp*. Kelp contains several soluble salts of potash, soda, and magnesia; and amongst others iodide of potassium or sodium; this is separated from the other salts by repeated crystallization; the iodide being more soluble, remains in solution. The liquor is then introduced into a stone-ware still, sulphuric acid and the binoxide of manganese are added, and heat is applied. The iodide is decomposed, sulphate of potassa or soda remains in the retort with the sulphate of the protoxide of manganese; and iodine distils over. PROPERTIES.—Iodine is usually met with



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in soft micaceous scales, having a greyish colour, a disagreeable odour, and a hot acrid taste. It is volatile, its vapour having a violet colour. It is soluble in alcohol and in ether, and slightly so in water. CHARACTERISTICS.—In its free state iodine is distinguished by its forming an intense blue colour with starch. EFFECTS.—In small doses iodine is considered as an alterative. In moderate doses, it increases the secretion of urine and of intestinal mucus; probably, too, that of the bile and of the pancreatic fluid; in some cases it produces salivation. It has a remarkable power of increasing the activity of the absorbents. Thus glandular enlargements frequently disappear under its use, and in some very rare cases, the mammæ of the females and the testicles of the male are said to have become absorbed. In large doses *iodine* acts as an irritant poison. USES.—Iodine is used with much benefit in *bronchocele*, in scrofula, and in various chronic diseases of the viscera. It is supposed to be occasionally efficacious as an emmenagogue. It is an useful remedy in some forms of the venereal disease. DOSE, about gr. ſs. It is seldom given alone, but usually in solution with iodide of potassium. ANTIDOTES.—In the event of poisoning by iodine, promote vomiting by the use of tepid demulcent drinks, especially such as contain starch, so that an iodide of starch may be formed, this having but little local action.

IPOMÆA JALAPA—*The Jalap.—Sex. syst. Pentandria. Monogynia. Nat. ord. Convolvulaceæ.* PART USED.—The dried tubers: they vary in size from that of the fist to that of a nut, and are covered with a thin brown, wrinkled cuticle. COMPOSITION.—The medicinal virtues of jalap reside in a *peculiar resin*. EFFECTS AND USES.—Jalap is a powerful purgative, producing copious liquid stools, and, when judiciously administered, it is both safe and efficacious. It very useful in obstinate constipation unattended with irritation or inflammation of the alimentary canal; as a vermifuge; in cerebral diseases, and in some forms of dropsy. DOSE.—From grs. v. to ℈j. In the Pharmacopœia there is a tincture and an extract.

JUNIPERUS COMMUNIS—*The Common Juniper.—Sex. syst. Diœcia. Monadelphia. Nat. ord. Coniferæ.* HAB.—North of Europe. PARTS USED.—The fruit and tops. The berries are about the size of a pea, of a blackish purple colour, covered by a glaucous bloom; they contain three seeds. COMPOSITION.—The berries contain *volatile oil*, *resin*, *wax*, and *sugar*. EFFECTS AND USES.—Juniper berries and tops are stimulant diuretics, and as such are used in dropsies and in some chronic diseases of the bladder. DOSE.—Of the berries one or two drachms.

JUNIPERUS SABINA—*Common Sabine.* HAB.—Middle and southern parts of Europe. PARTS USED.—The tops. COMPOSITION.—The most important constituents are *volatile oil* and *resin*. EFFECTS AND USES.—The local action of sabine is that of an irritant and rubefacient; taken internally, it acts as a stimulating diuretic and emmenagogue. In large doses it is an irritant poison, and in some cases has produced abortion. It is sometimes employed as an emmenagogue. The cerate is used to keep open blisters.

KINO.—Vide *Pterocarpus*.

KRAMERIA TRIANDRIA—*The Ratany.—Sex. syst. Tetrandria. Monogynia. Nat. ord. Polygaleæ.* HAB.—Peru. PART USED.—The root. COMPOSITION.—It contains about 40 per cent. of *tannin*. EFFECTS AND USES.—It is a powerful astringent and tonic, and is used in diarrhœa and in passive hæmorrhages. DOSE.—grs. x. to ʒ ſs.

LACTUCA SATIVA—*The Garden Lettuce.—Sex. syst Syngenesia. Polygamia Æqualis. Nat. ord. Compositæ.* HAB.—Extensively cultivated in Europe. PART USED.—The inspissated juice called *Lactucarium*. It exudes from incisions made in the flowering stem, and concretes. COMPOSITION.—Lactucarium contains *bitter extractive*, *wax*, *resin*, and *caoutchouc*. EFFECTS AND USES.—It is said to possess anodyne and sedative properties, and is used in some cases when opium disagrees. It is not a medicine of much value. DOSE.—grs. iij. to grs. v.

LAVANDULA VERA—*Common Lavender.—Sex. syst. Didynamia, Gymnospermia. Nat. ord. Labiatæ.* HAB.—South of Europe. PARTS USED.—The flowers. COMPOSITION.—They contain *volatile oil* and *tannin*. EFFECTS AND USES.—Carminative, slightly stimulant, and tonic. Chiefly used as adjuncts to other medicines. In the Pharmacopœia there is an *oil*, a *spirit*, and a *compound tincture of lavender*.

LINUM USITATISSIMUM—*Common Flax.—Sex. syst. Pentandria. Pentagynia. Nat. ord. Linaceæ.* HAB.—Indigenous. PARTS USED.—The seed, commonly called linseed. COMPOSITION.—The nucleus contains a large quantity of *fixed oil*, while the husk abounds in *mucilage*. EFFECTS AND USES.—Linseed is emollient and demulcent, and is used to allay irritation in the form of *infusion*, *oil*, or *cataplasm*. The cataplasm is made by adding to powdered linseed as much boiling water as may be sufficient to make it of a proper consistence.

LOBELIA INFLATA—*Bladder-inflated Lobelia; Indian Tobacco.—Sex. syst. Pentandria. Monogynia. Nat. ord. Lobeliaceæ.* HAB.—North America. PART USED.—The dried herb. It is compressed into oblong cakes. The dried herb has a pale greenish yellow colour, a nauseous smell, and a burning acrid taste, similar to that of tobacco. COMPOSITION.—Dr. Pereira states that it contains a *volatile acrid principle*, *an acid*, and *resin*. EFFECTS AND USES.—In small doses it acts as an expectorant and a diaphoretic. In full doses it acts powerfully as an emetic, causing extreme nausea, and great general relaxation. In excessive doses it is an acro-narcotic poison. Its action is very similar to that of the common tobacco. It has been chiefly given in spasmodic asthma; in strangulated hernia it may be used instead of tobacco. DOSE.—Of the powder, as an expectorant, from gr. j. to grs. v.; as an emetic, from grs. x. to ℈j. An alcoholic or an ethereal tincture may be used. ANTIDOTE.—The same as for tobacco.

MAGNESIÆ SULPHAS—*Sulphate of Magnesia.* PREPARATION.—It is obtained from *bittern* or from *dolomite*. Bittern is the mother-liquor of sea water from which the chloride of sodium has been separated by crystallization. It contains chloride of magnesium and sulphate of magnesia. The sulphate may be obtained by evaporation. Dolomite, or magnesian limestone, is composed of carbonate of lime and carbonate of magnesia. When sulphuric acid is added to this, carbonic acid escapes, and sulphate of magnesia and sulphate of lime are formed. These two salts are separated from each other by crystallization, the sulphate of lime being the least soluble. The properties of sulphate of magnesia or Epsom salts are sufficiently well known. EFFECTS AND USES.—It is a mild antiphlogistic purgative, promoting the secretions as well as the vermicular motion of the intestinal canal. It is much used in febrile and

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inflammatory diseases, and as an ordinary purgative in constipation. DOSE.—From ʒ ij. to ʒ j.

MAGNESIA—*Magnesia*. PREPARATION.—Obtained by heating the subcarbonate, so as to drive off the carbonic acid. PROPERTIES.—It is a fine light, white powder, odourless and tasteless. It is but slightly soluble in water. EFFECTS AND USES.—It neutralizes the free acids of the stomach, and in full doses it acts as a laxative. If long continued, it tends to render the urine alkaline. When taken in large quantities, for a very long period, it has sometimes accumulated in the intestines, and produced unpleasant and even dangerous consequences. It is given as an antacid in dyspepsia, and in the uric acid diathesis; as a laxative in diseases of children; and for adults when a very mild aperient is required. DOSE.—For adults, from ℈ j. to ʒ j.; for infants from grs. ij. to grs. x.

MAGNESIÆ SUBCARBONAS—*Subcarbonate of Magnesia*. PREPARATION.—Dissolve separately four pounds of sulphate of magnesia, and four pounds and eight ounces of carbonate of soda, in two gallons of water, and strain: then mix the liquors, and boil for a quarter of an hour, constantly stirring with a spatula: lastly, having poured off the liquor, wash the precipitated powder with boiling distilled water, and dry it. In this process double decomposition takes place. Carbonate of magnesia, being insoluble, precipitates, and sulphate of soda remains in solution. Some bicarbonate of magnesia is formed, and remains in solution with the soda, consequently the precipitate is a subcarbonate of magnesia, its composition being 4 eqs. magnesia and 3 eqs. carbonic acid. It is nearly insoluble in water, but readily dissolves in carbonic acid water. EFFECTS, USES, AND DOSES.—The same as those of the magnesia.

MARANTA ARUNDINACEA—*The Arrow-Root*.—*Sex. syst. Monandria. Monogynia. Nat. ord. Marantaceæ*. HAB.—West Indies. PART USED.—The fecula obtained from the tubers. The rhizomes are dug up when they are a year old, washed, beaten to a pulp, and agitated in water, so as to separate the fibrous from the feculaceous part. The milky fluid is strained through coarse linen, and left at rest until the fecula subsides, when the supernatant fluid being decanted, the fecula is well washed in fresh portions of water, and dried in the sun. EFFECTS AND USES.—Arrow-root forms a mild demulcent nutriment for children and for the sick.

MELALEUCA MINOR—*The Cajuput*.—*Sex. syst. Polyadelphio. Icosandria. Nat. ord. Myrtaceæ*. HAB.—Moluccas. PART USED.—The volatile oil extracted from the leaves. EFFECTS AND USES.—Cajuput oil is a powerful anti-spasmodic diffusible stimulant and sudorific. It is used in cramp of the stomach and in flatulent colic. DOSE.—From ♏ j. to ♏ x.

MENTHA VIRIDIS—*Spearmint*.—*Sex. syst. Didynamia. Gymnospermia. Nat. ord. Labiatæ*. HAB.—Indigenous. PART USED.—The whole herb. COMPOSITION.—*Volatile oil, resin*, and a *bitter principle*. EFFECTS AND USES.—Aromatic, carminative, and mildly stimulant. It is chiefly used as a flavouring ingredient. Pharmacopœial preparations, *oleum, spiritus*, and *aqua*.

MENTHA PIPERITA—*The Peppermint*.

MENTHA PULEGIUM—*The Pennyroyal*.—The composition, effects, and uses of these species are the same as those of the Mentha Viridis.

MENYANTHES TRIFOLIATA—*The Buck-bean*.—*Sex. syst. Pentandria. Monogynia. Nat. ord. Gentianaceæ*. HAB.—Indigenous. PART USED.—The whole herb. COMPOSITION.—Its active principle is a *bitter extractive*. EFFECTS AND USES.—Tonic, and, in large doses, cathartic. It is seldom used.

MEZEREI CORTEX.—Vide *Daphne*.

MOMORDICA ELATERIUM—*The Squirting Cucumber*.—*Sex. syst. Monœcia. Syngenesia. Nat. ord. Cucurbitaceæ*. HAB.—South of Europe; cultivated at Mitcham, in Surrey, and at Ampthill, in Bedfordshire. PART USED.—Elaterium is a sediment deposited from the juice immediately surrounding the seeds. PREPARATION.—The cucumbers should be gathered when as nearly ripe as possible; they should be cut through longitudinally, and the juice allowed to strain through a fine sieve. After standing a few hours a sediment is formed, from which the clear liquor is to be poured off; it is then to be thinly spread on fine linen, and exposed to the air to dry. If pressure is employed the elaterium becomes mixed with inert matters, which render its strength uncertain. Good elaterium is friable, has a pale greenish-grey colour, and no animal odour; thrown into water it swims; it does not effervesce in dilute hydrochloric acid; touched with tincture of iodine it gives no evidence of the presence of starch. English elaterium is the best. The Maltese elaterium is largely adulterated with chalk and starch. COMPOSITION.—The active principle is *elaterin*, of which good elaterium contains 26 per cent. It is a crystalline solid, insoluble in water, but soluble in hot alchohol. EFFECTS AND USES.—Elaterium is a violent hydragogue purgative, producing copious watery evacuations. Its chief use is for removing the fluid of dropsies. DOSE.—The dose of good elaterium is from gr. $\frac{1}{8}$ to gr. $\frac{1}{4}$.

MOSCHUS MOSCHIFERUS—*The Musk Animal*.—*Cl. Mammalia. Ord. Ruminantia*. PART USED.—Musk is contained in a sac situated in front of the prepuce; the musk sac exists only in the male animal. HAB.—Asia. ADULTERATION.—The Chinese adulterate musk, and even form artificial musk by a mixture of blood and ammonia with a small quantity of musk. The analysis of musk is unsatisfactory. EFFECTS AND USES.—Musk is a stimulant and antispasmodic, and is sometimes used in low fevers, and in some convulsive diseases, as hysteria. DOSE.—From grs. viij. to grs. xv. It may be given in substance or suspended in water by means of saccharine or mucilaginous substances.

MUCUNA PRURIENS—*The Cowhage*, or *Cow-itch*.—*Sex. syst. Diodelphio. Decandria. Nat. ord. Leguminosæ*. HAB.—West Indies. PARTS USED.—The bristly stinging hairs with which the pods are clothed. EFFECTS AND USES.—The hairs are used as an anthelmintic; they are supposed to act mechanically by irritating the worms and compelling them to shift their quarters. They are usually given in treacle or honey.

MYRISTICA MOSCHATA.—*The Nutmeg-Tree*.—*Sex. syst. Diœcia. Monadelphia. Nat. ord. Myristaceæ*. HAB.—Moluccas. COMPOSITION. The nutmeg contains a large proportion of *volatile oil*. EFFECTS AND USES.—In moderate doses nutmegs are aromatic stimulants and antispasmodics. In large doses they are narcotic, causing giddiness, delirium, and stupor. They are chiefly used for flavouring, and as a corrigent. DOSE.—℈ j. or ʒ ſs. The oil is given in doses of from ♏ j. to ♏ v.

MYROSPERMUM PERUIFERUM—*The Quinquino*.—*Sex. syst. Decandria. Monogynia. Nat. ord. Legumino-*



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*ræ*. Hab.—South America. Part used.—The balsam, which exudes when incisions are made into the bark of the tree. It is a transparent reddish-brown liquid, of the consistence of treacle, having an agreeable odour and a warm bitter taste. Composition.—Balsam of Peru contains an *oil*, *cinnamic acid*, and *resin*. Effects and Uses.—It is a stimulating expectorant, and is useful in chronic catarrh, and in some forms of asthma. Applied to indolent ulcers it sometimes has a good effect in cleansing them. Dose.—f. ʒ ss. to f. ʒ j.

Myrospermum Toluiferum—*The Balsam of Tolu-Tree.* Hab.—South America. The balsam is obtained by making incisions into the bark of the tree; when recent it is soft and tenacious, but by age it becomes hard and brittle, like resin. It is transparent, has a reddish-brown colour, and a most fragrant odour. Composition, Effects, and Uses.—Similar to those of the balsam of Peru.

Myrrha.—Vide *Balsamodendron.*

Nicotiana Tabacum—*The Tobacco Plant.* — *Sex. syst. Pentandria. Monogynia. Nat. ord. Solanaceæ.* Hab.—America. Parts used.—The leaves. Composition.—Tobacco leaves contain *a volatile acrid principle* (*nicotina*) and a *concrete volatile oil.* Effects.—In small doses tobacco produces nausea, giddiness, and an increased flow of urine. In larger doses it causes vomiting and purging, with great languor and relaxation of the muscles, extreme anxiety, and a tendency to faint. In excessive doses the effects are the same, but more violent in degree. The smoking of tobacco by those unaccustomed to it produces the same symptoms as those arising from its introduction into the stomach: in the form of enema the effects are precisely the same. Uses.—Tobacco is used in cases of colic, strangulated hernia, and constipation; its efficacy in those cases depending on its power of relaxing the muscular fibres, and on its purgative properties. It has also been used in tetanus and some other spasmodic diseases. It is administered in the form of enema; but the dangerous collapse which it sometimes induces renders most practitioners extremely cautious of this drug, and it is not frequently used. In the London Pharmacopœia the *enema tabaci* is ordered to be made by infusing one drachm of tobacco in a pint of boiling water; not more than one-third of this enema should be administered at a time. Antidotes.—In a case of poisoning by tobacco give coffee, and, if necessary, brandy and ammonia.

Nux Vomica.—Vide *Strychnos.*

Olea Europæa—*The European Olive.* —*Sex. syst. Diandria. Monogynia. Nat. ord. Oleaceæ.* Hab.—Levant, Barbary, south of Europe. Part used.—The oil expressed from the fruit. The oil resides in the pericarp, and is obtained by pressing the olives. Effects and Uses.—Like all the fixed oils, olive oil is extremely nutritious, but difficult of digestion. In large doses it acts as a laxative. It is sometimes given in cases of irritant poisoning to involve acrid substances and protect the stomach from their action. Its chief use is for the formation of liniments and ointments.

Opium.—Vide *Papaver.*

Opoponax Chironium—*The Opoponax.*—*Sex. syst. Pentandria. Monogynia. Nat. ord. Umbelliferæ.* Hab.—South of Europe. Part used.—The gum resin. It is probably obtained by incisions into the root: a milky juice exudes which, by drying, forms opoponax. Composition, Effects, and Uses.—Similar to those of the other fetid gum-resins.

Papaver Rhœas—*The Red Poppy.*—*Sex. syst. Polyandria. Monogynia. Nat. ord. Papaveraceæ.* Hab.—Indigenous. Parts used.—The petals. Composition.—The most abundant constituent is a red colouring matter. Effects and Uses.—The red poppy is scarcely if at all narcotic; its only use is as a colouring agent. In the Pharmacopœia there is a *Syrupus Rhœados.*

Papaver Somniferum—*The Somniferous or White Poppy.*—There are two varieties of this species, the *white* and the *black.* Hab.—Asia and Egypt. Parts used.—The capsules, and the opium obtained from the capsules: the capsules should be gathered before they are quite ripe, otherwise they lose much of their activity. Preparation of Opium.—Opium is obtained by making incisions into the half-ripe capsules; a white substance immediately flows out and collects in tears on the edges of the cuts. In this state the field is left for twenty-four hours, and on the following day the opium is collected by large blunt knives. Each head furnishes opium once only, and that to the extent of a few grains. In commerce several varieties of opium are known. The Smyrna opium is the best and most abundant. There is also the *Constantinople, Egyptian, Persian, Indian,* as well as the *English, French, and German opium.* Opium exists in masses of variable size; some kinds appear to be made up of agglutinated tears, while others have more the uniform appearance of an extract. It is generally of a reddish-brown colour, having a strong unpleasant odour, and a bitter, acrid, nauseous taste. Composition.—The following are stated to be the constituents of opium: *morphia, narcotina, codeia, narceia meconine, thebaina, meconic acid, brown acid extractive, sulphuric acid, resin, fat oil, gummy matter, caoutchouc, albumen, odorous principle,* and *lignin.* It is probable that several of these substances are the products of the processes employed for obtaining them, and that they do not all preexist in the opium. The two most important constituents are morphia and meconic acid, which exist in combination as meconate of morphia. *Morphia* presents itself in the form of transparent crystals; it has an alkaline re-action; it is nearly insoluble in water, but soluble in alcohol, oils, alkalies, and acids, with the last forming salts. Morphia has the following characteristics;—Nitric acid reddens it; iodic acid is deoxidized by it, iodine being set free, when it gives a blue colour with starch; sesquichloride of iron renders the crystals blue; infusion of galls gives a precipitate (tannate of morphia) in neutral solutions of the salts of morphia. Morphia and its salts have a bitter taste. *Meconic acid,* when pure, is in the form of white micaceous scales, soluble in four times their weight of boiling water. It reddens the sesqui-salts of iron, forming the meconate of the sesquioxide of iron, and gives white precipitates (meconates), which are soluble in nitric acid, with acetate of lead, nitrate of silver, and chloride of barium. Of the constituents of opium those which are said to be poisonous are, *morphia, codeia,* and *thebaina;* the rest are almost or altogether inert. *The purity and strength of opium* are best estimated by extracting and ascertaining the amount of morphia which it contains. Good opium ordinarily contains about eight per cent. of morphia. Effects.—In small doses, as from a quarter of a grain to one grain, opium usually acts as a stimulant; the pulse is increased in frequency, the mind is exhilarated, ideas flow

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more quickly, a pleasurable state of the system is induced, and there is a capability of greater exertion. These symptoms are followed by a diminution of muscular power and a desire of repose, with a tendency to sleep. In a *full medicinal dose*, the stage of excitement is soon followed by that of depression, and there is an irresistible desire to sleep. After waking there is often some nausea, furred tongue, headache, and listlessness. *Effects of a poisonous dose.*—The symptoms of poisoning with opium, when it is administered at once in a dangerous dose, begin with giddiness and stupor, generally without any previous stimulus; the stupor rapidly increasing, the person becomes motionless and insensible to external impressions; he breathes very slowly, generally lies quite still, with the eyes shut, and the pupils contracted, and the whole expression of the countenance is that of deep and perfect repose. As the poisoning advances the features become ghastly, the pulse feeble and imperceptible, the muscles exceedingly relaxed, and, unless assistance is speedily procured, death ensues. If the person recovers, the stupor is succeeded by prolonged sleep, which commonly ends in twenty-four or thirty-six hours, and is followed by nausea, vomiting, giddiness, and loathing of food. The *habitual use of opium*, either for chewing or smoking, is said to have a most injurious effect upon the health; but there appears some reason to doubt the accuracy of the statements which have been made on this point. The only constant effect of opium-eating is constipation. *Effect of opium on the different organs.*—1. *On the Nervous System.* It diminishes sensibility, allays pain and spasm, or convulsive movements of the muscles, and promotes sleep. 2. *On the Digestive System.* It diminishes secretion, producing dryness of the mouth, thirst, retarding the digestive process, and producing constipation. 3. *On the Vascular System.* Its effect is not uniform; it generally acts first as an excitant, and subsequently as a sedative. 4. *On the Respiratory System.* It checks the secretion of the bronchial mucous membrane, and retards expectoration; at the same time it appears to interfere with the arterialization of the blood. 5. *On the Cutaneous System.* It increases the secretion by a stimulating effect. The above is a very general statement of the influence of opium on the most important sets of organs. Uses.—The uses of opium may be in a great measure inferred from a knowledge of its physiological effects. We can only very briefly mention the most important diseases in which this very valuable medicine is employed. In fevers it is used to relieve watchfulness and restlessness, delirium, tremor, and diarrhœa. In inflammations it is used to relieve pain, to act as a sedative, and to promote the action of mercury. In diseases of the brain and spinal cord;—thus, in delirium tremens to procure sleep, and in tetanus to remove convulsions. In some diseases of the chest it is used to allay cough and irritation, but its use in these cases requires great caution. In some diseases of the urinary organs it is used to allay pain and irritation. It is used in mortification, in venereal diseases, in rheumatism, and in a multitude of cases which it would be tedious and useless to mention. There is, perhaps, no one remedy so valuable and so extensively used as opium. Dose.—Opium may be given in substance in doses of from gr. ½. to grs. iij., according to the effect which we wish to produce, and the nature of the disease in which it is administered. Thus, a patient with tetanus will take an almost incredible quantity of opium without appearing to be in any way affected by it. The *tincture* of the Pharmacopœia contains one grain of opium in ♏xix.

The salt of morphia which is most commonly used is the hydrochlorate. The directions for its preparation are long and somewhat complex. In a few words, it consists essentially in this:—Macerate opium in water; the result is a solution of meconate of morphia; add to this a solution of chloride of lead; we thus obtain an insoluble precipitate of meconate of lead and a solution of hydrochlorate of morphia. This is purified by digesting with animal charcoal, and is obtained in a crystalline state by evaporation. In comparing the action of morphia and its salts with that of opium, the former are observed to be less stimulant and less disposed to cause headache, sweating, constipation, and dryness of the tongue; the stimulant effect of morphia too is less than that of opium. The dose of the salts of morphia is from gr. ⅛. to gr. ¼. Antidotes.—In a case of poisoning by opium, the first indication is to remove the poison from the stomach; this may be done by the stomach-pump, if at hand, or by emetics of sulphate of zinc or copper, mustard or salt, or by tickling the throat with a feather. Having removed the poison from the stomach, we must endeavour to counteract the injurious effects of any portion of it which may have become absorbed. The patient must be roused by every means calculated to have such an effect,—by walking him about between two men, by cold affusion, by irritants, such as blisters or sinapisms, taking care that the latter be not allowed to remain on sufficiently long to produce sloughing. There is one proceeding which will often rouse the patient when all others have failed; it consists in allowing the patient to lie on the bed, removing the shoes and stockings, and flicking the soles of the feet with a towel, the corner of which has been dipped in cold water. Stimulants must be administered, such as ammonia and coffee, and, in extreme cases, artificial respiration and electricity to the chest must be resorted to.

Phosphorus. Preparation.—It is obtained from bone-ash, by digesting it in sulphuric acid, by which sulphate and superphosphate of lime are procured; the first precipitates while the latter remains in solution. The solution is to be evaporated nearly to dryness, then mixed with charcoal, and distilled in an earthen retort; the charcoal abstracts the oxygen from the phosphoric acid of the superphosphate, setting free the phosphorus, which is volatilized. Properties.—It is a pale yellow, semi-transparent, highly combustible solid. It is insoluble in water, but soluble in ether and oils. Effects and Uses.—In small doses it is a powerful diffusible stimulant, and in large doses it is an irritant poison. It is seldom given internally. Antidote.—In a case of poisoning by phosphorus we must give oil or some other liquid which may envelop it and prevent its oxidation, as it is by attracting oxygen and thus becoming converted into an acid that phosphorus acts as a caustic when swallowed. At the same time magnesia should be given to neutralize any acid which may be formed.

Physeter Macrocephalus—*The Spermaceti Whale.* —*Cl. Mammalia. Ord. Cetacea.* Hab.—Pacific Ocean, Indian and Chinese Seas. Extraction of Spermaceti.—In the right side of the nose and upper surface of the head of the whale is a triangular cavity;

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into this the whalers make an opening, and take out the contents (oil and spermaceti) by a bucket. In cold weather the spermaceti is a congealed solid, and it is separated from the oil, with which it was combined in the cavity of the head, by filtering. Effects and Uses.—Spermaceti is emollient and demulcent; it is seldom given internally, its chief medicinal use being for the preparation of ointments and cerates.

Pinus—*The Pine.*—*Sex. syst. Monœcia. Monadelphia. Nat. ord. Coniferæ.*—Several species of *Pinus*, also some species of *Abies* and *Larix*, yield the various medicinal substances obtained from the coniferous family. *Turpentine* is obtained by making incisions into the trees; the turpentine exudes, and is collected and placed in casks. Composition.—There are several varieties of turpentine, but they have all the same general composition. The most abundant constituents are *volatile oil* and *resin*. Effects and Uses.—Turpentine is a stimulating expectorant, diuretic, and diaphoretic. In large doses it produces vomiting and purging. It is used in chronic discharges from the urinary organs, in chronic catarrh, and in chronic rheumatism. It is sometimes used as a local application to indolent ulcers. Dose, ℈ j. to ʒ j.

*Oil of Turpentine* is obtained by submitting to distillation a mixture of turpentine and water; the oil distils over with the water and floats on its surface. Properties.—It is a colourless, limpid, inflammable liquid, having a peculiar odour and a hot taste. It is composed of carbon and hydrogen. Effects and Uses.—In small doses its action is the same as that of turpentime, and in full doses it produces a feeling of intoxication, and subsequently acts as a smart purgative; in some cases it produces excessive irritation of the urinary organs, and this effect is more likely to occur when it does not pass off freely by the bowels. Oil of turpentine is a valuable remedy against the tapeworm; it is also used in chronic discharges from the mucous membranes, in puerperal fever, in rheumatism, and in some other cases which we need not particularly mention. Dose.—As a diuretic, ♏x. to f. ʒ j.; as a general stimulant, ʒ j. or ʒ ij.; and as an anthelmintic, f. ℥ ſs. to f. ℥ ij. *Resin* is the residue of the process for obtaining oil of turpentine; its chief use is in the formation of plaster and ointments, which renders very adhesive, and slightly stimulant.

Piper Nigrum—*The Black Pepper.*—*Sex. syst. Diandria. Trigynia. Nat. ord. Piperaceæ.* Hab.—East and West Indies. Parts used.—The berries. Composition.—*Resin, volatile oil, and piperin.* Effects and Uses.—Pepper is an acrid stimulant and diaphoretic; it is sometimes used in ague, and it has a beneficial effect in some diseases of the rectum. Dose.—from grs. v. to grs. xv. In the Pharmacopœia there is a *confection of black pepper*, which is often very useful in piles.

Piper Longum—*The Long Pepper.* Hab.—India. Composition, Effects, and Uses.—Analogous to those of black pepper.

Piper Cubeba—*The Cubeb Pepper.* Hab.—Java. Parts used.—The dried, unripe fruit. Composition.—Analogous to that of black pepper. Effects and Uses.—Cubebs are acrid stimulants; they exercise a specific influence over the urino-genital organs. Their chief use is in gonorrhœa; they may be given with safety in the early stage of the disease, and they sometimes arrest it at once. Dose, grs. x. to ʒ ij.

Pistacia Terebinthus—*The Turpentine Pistacia.*—*Sex. syst. Diœcia. Pentandria. Nat. ord. Terebinthaceæ.* Hab.—Syria and the Grecian Archipelago. Part used.—The turpentine, which is extracted by making incisions into the trunk of the tree. It is called Chian or Cyprus turpentine. Composition, Effects, and Uses.—Similar to those of the coniferous turpentines.

Plumbum—*Lead.* Preparation.—Metallic lead is usually extracted from galena (native sulphuret of lead). The galena is roasted, by which it is converted into a mixture of sulphate and oxide of lead, and afterwards smelted with coal and lime, the first to abstract oxygen, the second to remove the sulphur. Characteristics.—If lead be dissolved in nitric acid we may recognize its presence by the following tests:—Alkalies and their carbonates, and sulphuric acid and the sulphates, give white precipitates; iodide of potassium gives a yellow precipitate, and sulphuretted hydrogen a black one; a piece of zinc placed in the solution throws down metallic lead in the arborescent form. Effects.—Metallic lead is probably inert. The *salts of lead*, in small doses, act on the alimentary canal as astringents; when absorbed they act as general astringents, checking hæmorrhages and the secretions of the skin and mucous membrane. The long-continued use of the preparations of lead is followed by the most disastrous effects upon the muscular and nervous systems. One of these consequences is lead colic, another palsy of the extensor muscles of the fore arm, called *wrist-drop*; in extreme cases all the muscles waste and become exceedingly weak. In some cases epileptic fits occur, and even apoplexy. After death in these cases, lead can be detected in all the tissues, abundantly in the brain and muscles. Workmen in lead often present all the above-mentioned symptoms. The same consequences sometimes result from living in freshly-painted rooms, or from drinking water which has been kept in leaden vessels. It is remarkable that the water which is most free from alkaline and earthy salts is most likely to act upon and dissolve lead. If we examine the mouth of any person whose system is contaminated with lead, we meet with evidence of the fact in the presence of a blue line at the margin of the gum surrounding each tooth. Uses.—The preparations of lead are given internally to check hæmorrhage, and excessive secretion, and exhalation. They are sometimes applied locally to subdue inflammation.

Plumbi Acetas—*Acetate of Lead.* Preparation.—By dissolving oxide of lead in acetic acid; this is commonly called *sugar of lead*. It has a sweetish astringent taste, and is soluble in both water and alcohol. Characters.—It is known to be the acetate by the vapour of acetic acid, which it gives off when heated with sulphuric acid. Composition.—One eq. oxide of lead, one eq. acetic acid. Effects and Uses.—Those of the compounds of lead generally. This is the salt which is most commonly employed; in large doses it acts as a slightly irritant poison. Dose, gr. j. or gr. ij. Much more may be given in a dose. Its use should not be long continued. Antidotes.—Solutions of the sulphate of potash, soda, or magnesia.

Plumbi Diacetatis Liquor—*Solution of the Diacetate of Lead.* Preparation.—By boiling acetate of lead with the oxide of lead. It is a transparent colourless liquid, and contains in solution a salt of lead, composed

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of 2 eqs. oxide of lead, and 1 eq. acetic acid. USES.—It is used, when diluted, forming *Goulard water*, as a local application to inflamed surfaces. It is a constituent of the *Ceratum Plumbi Compositum*.

POLYGALA SENEGA—*Sex. syst. Diadelphia. Octandria. Nat. ord. Polygaleæ*. HAB.—United States of America. PARTS USED.—The roots. The taste of the root is at first sweetish, afterwards acrid and pungent. COMPOSITION.—The active principle is *polygalic acid*. EFFECTS AND USES.—In small doses it is a stimulating diaphoretic, diuretic, and expectorant; in large doses emetic and purgative. Its chief use is in the latter stages of acute, and in chronic bronchitis. DOSE.—Of the powder, grs. x. to ℈ j. It is best given in the form of *decoction*.

POTASSA.—*Potash*.

POTASSÆ LIQUOR—*Solution of Potash*. PREPARATION.—Add fresh burnt lime to a solution of the carbonate of potash; when cold the supernatant liquor is to be poured off; this is the liquor potassæ; the carbonate of lime is precipitated. PROPERTIES.—It is a limpid, colourless, transparent liquid, having an acrid caustic taste: it corrodes flint glass, and must be kept in green glass bottles. CHARACTERISTICS.—Potash, free or combined, has the following characters:—It gives no precipitate with the hydro-sulphurets, ferrocyanides, or carbonates; tartaric acid in excess gives a precipitate of the bitartrate; chloride of platinum gives a yellow precipitate; the salts of potash give a violet tinge to the flame of alcohol. EFFECTS.—The local action of solution of potash is that of a caustic; it forms soluble compounds with albumen and fibrin. Internally, in small doses, diluted, it neutralizes the free acids of the stomach; hence the continued use of alkalies impairs the digestive powers. If the quantity taken be more than sufficient to neutralize the free acids of the stomach, it becomes absorbed and acts on the urine, rendering it alkaline, and favouring the deposit of the phosphates; it also increases the quantity of the urine. The continued use of alkalies is said to increase the activity of the absorbents, and, after a time, to produce a condition of the system analogous to scurvy. In large doses liquor potassæ acts as an irritant poison, corroding the stomach, and frequently producing perforation. USES.—Liquor potassæ is used as an antacid in dyspepsia, to alter the quality of the urine in the lithic acid diathesis, to remove induration and enlargement of the glands, and in syphilis and scrofula. DOSE.—from ♏x. to ♏xxx. ANTIDOTES.—Acids or oils.

POTASSÆ HYDRAS—*Hydrate of Potash*—prepared by evaporating the liquor potassæ to dryness; the residual mass is then fused and poured into moulds. COMPOSITION.—One eq. potassæ, one eq. water. EFFECTS AND USES.—It is an exceedingly energetic caustic, and is used for making issues, and for the other purposes for which caustics are required. The use of it requires caution, as it is apt to spread further than is intended.

POTASSÆ CARBONAS—*Carbonate of Potash*. PREPARATION.—It is obtained either by lixiviating woodashes, or by heating bisulphate of potash in a furnace with charcoal. In the latter process the oxygen of the sulphuric acid is abstracted by the carbon, and sulphuret of potassium remains; by further heating, the potassium combines with oxygen from the air, and with carbonic acid from the combustion of the charcoal, and thus we obtain carbonate of potash. COMPOSITION.—One eq. carbonic acid, one eq. potash. EFFECTS AND USES.—The effects of carbonate of potash are of the same kind as those of the liquor potassæ, but less in degree; it is used in the same cases. It is sometimes used for making the effervescing draught, with citric or tartaric acid. DOSE.—grs. x. to ʒ fs. ANTIDOTE.—Acids or oils.

POTASSÆ BICARBONAS—prepared by passing carbonic acid gas through a solution of the carbonate of potash. It contains one eq. carbonic acid more than the carbonate. EFFECTS AND USES.—Similar to those of the carbonate; its local action is less. It is often used in making the effervescing draught. The proportions are 20 grains of the bicarbonate to 14 grains of citric acid, 15 grains of tartaric acid, ʒ iij. fs, of lemon-juice. DOSE, grs. x. to ʒ fs.

POTASSÆ BITARTRAS—*Cream of Tartar*.—It is obtained from the interior of wine casks, where it is deposited during the fermentation of the grape-juice in which it was dissolved. PROPERTIES.—This salt forms a white crystalline mass, having an acid gritty taste. It is very slightly soluble in water. EFFECTS AND USES.—In small doses it is a refrigerant and diuretic, and in larger doses purgative. It is used for making refrigerant drinks in febrile and inflammatory diseases, as a diuretic in dropsy, and as a purgative combined with jalap or some other purgative.

POTASSÆ NITRAS—*Nitrate of Potash*. PREPARATION.—The nitre consumed in this country is imported from India. It there developes itself on the surface of the soil in the form of a thin white efflorescence, resembling frost-rind. It is collected and purified by solution, filtration, and crystallization. It may also be formed artificially. COMPOSITION.—One eq. nitric acid, one eq. potash. EFFECTS AND USES.—In small doses nitre is diuretic and refrigerant; in large quantities it acts as an irritant poison. It is much used in febrile and inflammatory diseases, combined with other saline medicines. DOSE, grs. x. to ʒ fs.

POTASSII IODIDUM—*Iodide of Potassium*. PREPARATION.—An Iodide of iron is first formed by heating iodine with iron filings in water; a solution of carbonate of potash is then added, carbonate of iron precipitates, and iodide of potassium remains in solution. The liquor is poured off, and, by evaporation, crystals of Iodide of potassium are obtained. PROPERTIES.—This salt occurs on white shining cubes or octabedrons: it is soluble in both water and alcohol. COMPOSITION.—One eq. iodine, one eq. potassium. EFFECTS AND USES.—The effects and uses are similar to those of iodine. It is a most valuable remedy in some forms of secondary syphilis, especially when the periosteum is affected. It is frequently given in combination with iodine. DOSE, usually about grs. iij.

POTASSII BROMIDUM—prepared in the same way as the iodide. It has been used with great success in cases of enlarged spleen. Some other salts of potash are occasionally used. We can do no more than enumerate them: *P. Sulphas, P. Bisulphas, P. Tartras, P. Acetas, P. Sulphuretum, P. Ferrocyanidum, P. Chloras*.

POTENTILLA TORMENTILLA—*The Tormentil*.—*Sex. syst. Icosandria. Polygynia. Nat. ord. Rosaceæ*. HAB.—Indigenous. PART USED.—The root. COMPOSITION.—It contains *tannin* in considerable quantities. EFFECTS AND USES.—It is tonic and astringent. Used in chronic diarrhœa and passive hæmorrhages. DOSE,

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ʒ ſs. to ʒ j. The best form for administering it is the *decoction*.

Pterocarpus Erinaceus—*The Hedgehog Pterocarpus.*—*Sex. syst. Diadelphia. Decandria. Nat. ord. Leguminosæ.* Hab.—Woods of the Gambia; Senegal. When an incision is made into the bark of this tree, a juice exudes and concretes. It is at first pale, but by exposure to the air it assumes a deep red hue. Two substances are met with in commerce under the name of kino; one is the inspissated juice of eucalyptus resinifera, the other is imported from India; the tree which yields it is not known; probably it is not the pterocarpus. Composition.—Kino contains a large proportion of *tannin*, with some *gum*. Effects and Uses.—It is tonic and astringent in diarrhœa, leucorrhœa, &c. Dose, grs. x. to ʒ ſs. The tincture is sometimes used.

Punica Granatum—*The Pomegranate.*—*Sex. syst. Icosandria. Monogynia. Nat. ord. Granateæ.* Hab.—Northern Africa. Introduced into Europe. Parts used.—The rind of the fruit and the bark of the root. Composition.—Both these parts contain *tannin* and *resin*. Effects and Uses.—Astringent; the bark of the root in the form of decoction is used as a remedy against tape-worm. The rind of the fruit may be given as an astringent and tonic.

Quassia or Picræna Excelsa—*The Quassia Tree.*—*Sex. syst. Decandria. Monogynia. Nat. ord. Simarubiaceæ.* Hab.—Jamaica. Part used.—The wood, which is white and has an extremely bitter taste. Composition.—It contains a bitter principle, *quassite*. Effects and Uses.—It is a simple bitter tonic, and is usefully given in dyspepsia, and in the convalescence from acute diseases. It is usually given in the form of *infusion*.

Quercus Pedunculata—*The Common British Oak. Sex. syst. Monœcia. Polyandria. Nat. ord. Cupuliferæ.* Hab.—Indigenous. Part used.—The bark. Composition.—It contains large quantities of tannic and gallic acid. Effects and Uses.—Oak bark is a powerful astringent and tonic. It may be used as a gargle in relaxed sore throat, as an astringent wash or injection, or it may be taken internally in diarrhœa and dysentery. Dose, in powder, ʒ ſs. to ʒ ij. The *decoction* is the best form.

Quercus Infectoria—*The Gall or Dyer's Oak.*—Hab.—Asia Minor. Part used.—The nut-galls. An insect pierces the bark of the shoots, and deposits its egg in the wound. The irritation thus produced gives rise to an influx of juices to the wounded part, and an excrescence forms which is called a gall. Composition.—The chief constituents are tannic and gallic acid. Effects and Uses.—Galls are powerful astringents, and as such are used in hæmorrhages and in chronic mucous discharges. Galls may be used as an antidote in poisoning by those vegetables whose activity depends on an alkali, as opium, nux vomica, &c., with which the tannic acid in the galls forms an insoluble salt. Galls may be used as a local astringent. Dose, grs. x. to grs. xx.

Quinia.—Vide *Cinchona.*

Rheum—*The Rhubarb.*—*Sex. syst. Enneandria. Monogynia. Nat. ord. Polygonaceæ.*—It is not yet ascertained what species of *Rheum* yields the officinal rhubarb. Several kinds of rhubarb are found in commerce, viz.: *Russian, Dutch-trimmed, Chinese, Himalayan, English,* and *French.* Composition.—Rhubarb contains *odorous* and *colouring matter, tannin, bitter principle, rhaponticin, oxalate of lime.* Effects and Uses.—In small doses rhubarb acts as an astringent tonic. In larger doses it operates slowly and mildly as a purgative; its purgative action is followed by an astringent effect. It is a useful purgative for children. It is given in some cases of diarrhœa, and as a stomachic and tonic in dyspepsia. Dose, as a purgative, from ℈ j. to ʒ j. In the Pharmacopœia there is an *infusion, a compound tincture,* and an *extract.*

Ricinus Communis—*The Castor Oil Plant.*—*Sex. syst. Monœcia. Monadelphia. Nat. ord. Euphorbiaceæ.* Hab.—East and West Indies. Part used.—The oil expressed from the seeds. The best oil is that which is obtained without the aid of heat. Effects and Uses.—It is a mild but certain purgative, acting very quickly, and seldom griping. It may be given in all cases where an unirritating purgative is required. Dose, f. ʒ ſs. or ʒ j.

Rosa Canina—*The Dog Rose.*—*Sex. syst. Icosandria. Polygynia. Nat. ord. Rosaceæ.* Hab.—Indigenous. Part used.—The pulp of the *hip.* Effects and Uses.—It is slightly refrigerant and astringent. It is used for making the *Confectio Rosæ Caninæ,* which is an agreeable vehicle for other remedies.

Rosa Gallica—*The French or Red Rose.* Hab.—South of Europe. Parts used.—The petals. Effects and Uses.—Slightly astringent and tonic. Chiefly used for their colour and flavour.

Rosa Centifolia—*The Hundred-Leaved or Cabbage Rose.* Hab.—Asia. Cultivated at Mitcham. Parts used.—The petals. Effects and Uses.—The petals are mildly laxative, and are employed on this account in the form of syrup. They are also used for their odour in the distillation of rose-water.

Ruta Graveolens—*The Common Rue.*—*Sex. syst. Decandria. Monogynia. Nat. ord. Rutaceæ.* Hab.—South of Europe. Cultivated in gardens. Part used.—The herb. Composition.—It contains *volatile oil* and *bitter extractive.* Effects and Uses.—Rue is a stimulant antispasmodic, and is supposed to be emmenagogue. It is very efficacious in the flatulent colic of children. It is best given in the form of *infusion.*

Sabina.—Vide *Juniperus.*

Sagapenum.—Vide *Ferula.*

Sapo—*Soap.*—Soap is a compound of margaric and oleic acids, with an alkaline, or an earthy, or an oxidized metallic base. The first kind is used in medicine. There are two kinds of alkaline soap; one made with soda, and called *hard soap;* the other made with potassa, and called *soft soap.* Effects and Uses.—Soap is purgative. It is seldom given alone, but it is a constituent of many of the pills ordered in the Pharmacopœia.

Sarsaparilla.—Vide *Smilax.*

Sassafras Officinale—*The Sassafras Tree.*—*Sex. syst. Enneandria. Monogynia. Nat. ord. Lauraceæ.* Hab.—North America. Part used.—The wood. Effects and Uses.—A stimulant, sudorific, and alterative, in rheumatic and venereal diseases. It is a constituent of the *Decoctum Sarzæ Compositum.*

Scammonia.—Vide *Convolvulus.*

Scilla Maritima—*The Squill.*—*Sex. syst. Hexandria. Monogynia. Nat. ord. Liliaceæ.* Hab.—Shores of the Mediterranean. Parts used.—The bulbs. Two kinds of squills are met with, *white* and *red,* from the colour of their scales. Composition.—*An acrid matter,* and *scillitin.* Effects and Uses.—In small doses a

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stimulating expectorant and diuretic; in large doses, emetic and purgative. In excessive doses it is an acrid poison. It is used as a diuretic in dropsies, and as an expectorant in chronic pulmonary affections. Dose, of the powder as an expectorant or diuretic, gr. j. The following preparations are used:—*Tinctura*, *Acetum*, and *Oxymel Scillæ*.

Senna.—Vide *Cassia*.

Simaruba Officinalis—*Mountain Damson*.—*Sex. syst. Decandria. Monogynia. Nat. ord. Simarubaceæ.* Hab.—West Indies. Part used.—The bark of the root. Effects and Uses.—In small doses it is a bitter tonic; in large ones, emetic and purgative. It has been chiefly used in dysentery. It may be given in the form of *infusion*.

Sinapis Nigra—*The Black Mustard*.—*Sex. syst. Tetradynamia. Siliquosa. Nat. ord. Cruciferæ.* Hab.—Indigenous. Part used.—The seed. Effects and Uses.—Mustard is an acrid stimulant: applied to the skin it produces rubefaction, vesication, and ulceration, if allowed to remain sufficiently long. Internally, in moderate doses, it is a stimulant, promoting the appetite and digestion: in larger doses it is emetic. It may be used as an emetic in cases of narcotic poisoning. The mustard cataplasm is applied to the skin as a counter-irritant, or to rouse the system in affections of the brain. As an emetic, the dose is from a tea-spoonful to a table-spoonful of the flour in water.

Sinapis Alba—*White Mustard*. Effects and Uses.—Similar to those of the black. It is less acrid than the black.

Smilax—*Several species yielding Sarsaparilla*.—*Sex. syst. Diœcia. Hexandria. Nat. ord. Smilaceæ.* Hab.—South America. Parts used.—The roots. Composition.—*Volatile oil*, *smilacin*, *starch*, *resin*, and *extractive*. Effects and Uses.—Sarsaparilla is diuretic, diaphoretic, nutritive, and an alterative tonic. It is given in some forms of syphilis, rheumatism, and cutaneous diseases. It is usually given in the form of *decoction*, either simple or compound; there is also a syrup and an extract.

Sodæ Carbonas—*Carbonate of Soda*. Preparation.—It is obtained from the ashes of sea-side plants, and from sulphate of soda in the same manner as carbonate of potash is obtained from the sulphate. Characteristics.—It is distinguished from the salts of potash by not giving a precipitate with tartaric acid, or with chloride of platinum, and by the yellow tinge which it communicates to the flame of alcohol. Effects and Uses.—The same as those of carbonate of potash.

Sodæ Bicarbonas—prepared in the same manner as the bicarbonate of potash, and used in the same cases.

Sodii Chloridum—*Chloride of Sodium* (*common salt*)—prepared by evaporating the water of brine springs. Effects and Uses.—This salt probably serves some important purposes in the economy; it always exists in the blood. In small doses it seems to act as a tonic and alterative; in larger doses it is an emetic and purgative. It is not much used as a medicine, but is sometimes given as an emetic in doses of two or three table-spoonfuls. It forms an useful enema; and a solution in water is sometimes used as a bath.

Sodæ Chlorinatæ Liquor—prepared by passing chlorine into a solution of carbonate of soda. Effects and Uses.—The same as those of calcis hypochloris. Dose.—♏xx. or more.

Sodæ Biboras—*Borax*.—This salt is used as a detergent in the form of gargle, or of the *Mel Boracis* in cases of aphthæ and ulceration of the mouth in infants.

Sodæ Sulphas—This is a purgative salt, in doses of ʒss. to ʒj.

Sodæ Potassio-Tartras.—This is a double tartrate of soda and potash. It is a mild laxative in doses of ʒss. to ʒj.

Sodæ Acetas is diuretic in doses of from ℈j. to ʒij. Its chief use is in the preparation of acetic acid.

Solanum Dulcamara—*Woody Nightshade*.—*Sex. syst. Pentandria. Monogynia. Nat. ord. Solanaceæ.* Hab.—Indigenous. Part used.—The stems. Effects and Uses.—It is slightly diuretic and diaphoretic. In large doses it is said to be an acro-narcotic poison. It is thought to be useful in some chronic skin diseases. It is given in the form of decoction.

Spigelia Marilandica—*The Indian Pink*.—*Sex. syst. Pentandria. Monogynia. Nat. ord. Spigeliaceæ.* Hab.—North America. Parts used.—The root. Effects and Uses.—In moderate doses it is vermifuge without producing any sensible effect on the system, in large doses it is an acro-narcotic poison. It is used only as a vermifuge. Dose.—For an adult ʒj. to ʒij. of the powdered root.

Spiritus Rectificatus—Sp. gr. 838. It is used as a pharmaceutical agent.

Spiritus Tenuior—*Proof Spirits*.—Sp. gr. 920. It is a powerful diffusible stimulant. It is chiefly used for preparing *tinctures* and the *spirits* of the Pharmacopœia.

Spiritus Vini Gallici—*Brandy*.

Spiritus Etheris Nitrici—prepared by adding nitric acid to rectified spirit, and distilling. It is a compound of ether and hyponitrous acid. Effects and Uses.—It is refrigerant, diuretic, and diaphoretic; used in dropsies and in febrile and inflammatory diseases. Dose f. ʒss. or f. ʒj.

Stannum—*Tin*.—Tin filings are sometimes used as an anthelmintic: their *modus operandi* is not well known, but they are generally supposed to act mechanically. An ounce of powdered tin may be given in treacle.

Strychnos, Nux Vomica—*The Poison Nut*.—*Sex. syst. Pentandria. Monogynia. Nat. ord. Apocynaceæ.* Hab.—India, Ceylon. Parts used.—The seeds. They are round, peltate, concave on one side, convex on the other. The testa is covered by short silky hairs. Composition.—The seeds and the bark contain two alkalies, *strychnia* and *brucia*, which have an intensely bitter taste. Effects.—In small doses nux vomica is tonic and diuretic. In large doses it produces convulsions and rigidity of all the muscles; in excessive doses, a condition like tetanus is induced, and the animal dies from asphyxia. The effect of nux vomica, and of its alkalies is directly the reverse of that of *conia*. Uses.—Nux vomica and strychnia have been used with success in some cases of palsy, in amaurosis, and in some other affections of the nervous system. Its use should not be long continued, as it is apt to accumulate and suddenly produce violent symptoms. Dose.—Of powdered nux vomica, grs. ij. of strychnia, gr. $\frac{1}{16}$.

Styrax Officinale—*The Storax*.—*Sex. syst. Decandria. Monogynia. Nat. ord. Styraceæ.* Hab.—The Levant. Storax exudes from incisions made into the stem of the tree. Composition.—*Volatile oil*, *resin*, *benzoic acid*. Effects and Uses.—It is a stimulating expectorant, and is chiefly used in chronic bronchial affections. Dose, grs. v. to grs. x.



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Styrax Benzoin.—*The Benjamin Tree.* Hab.—Sumatra, Borneo, Java, Siam. It is obtained in the same manner as storax. Its composition, effects, and uses are also analogous. Dose, grs. x. to ʒ ſs. It is seldom given alone: in the Pharmacopœia there is a preparation called *Tinctura Benzoini Composita*.

Sulphur is found native in the neighbourhood of volcanoes, and is purified by distillation. Effects and Uses.—It is laxative and a stimulating diaphoretic. As a laxative it is used in cases of piles, and as a diaphoretic in some chronic cutaneous diseases. It is a specific for the itch, applied in the form of ointment. Dose, ℈ j. to ʒ ij. in treacle.

Tamarindus Indica—*The Tamarind*—is used for its pulp, which is refrigerant and laxative. It is seldom given alone, but is one of the constituents of the *confectio sennæ*.

Valeriana Officinalis—*The Valerian.—Sex. syst. Triandria. Monogyia. Nat. ord. Valerianaceæ.* Hab.—Indigenous. Parts used.—The root. Composition.—*Volatile oil*, a *volatile acid*, and *resin*. Effects and Uses.—It is stimulant and antispasmodic. It may be given in hysteria. Dose, ℈ j. to ʒ j.

Veratrum Album—*The White Hellebore.—Sex. syst. Polygamia. Monœcia. Nat. ord. Melanthaceæ.* Hab.—Mountainous regions of Europe. Part used.—The rhizome. Composition.—It owes its activity to *veratria*. Effects.—It is a violent cathartic, emetic, and sternutatory: in large doses it produces bloody stools, sinking of the pulse, tremblings, convulsions, and death. Uses.—It has been used in some affections of the nervous system, in chronic skin diseases, and in gout. Dose, gr. j. In the Pharmacopœia, there is a *vinum veratri*. There is also a *decoction* and an *ointment* for local application.

Zinci Sulphas—*Sulphate of Zinc*—prepared by dissolving zinc in dilute sulphuric acid, and evaporating to dryness. Composition.—1 eq. sulphuric acid, 1 eq. oxide of zinc. Effects and Uses.—In small doses it is astringent, tonic, and antispasmodic. In full doses it is a safe and quickly acting emetic: in excessive doses it is an irritant poison. As an emetic it is used in cases of narcotic poisoning: as an astringent in diarrhœa and in chronic discharges from the urinary and bronchial mucous membrane; as a tonic and antispasmodic, it is used in chorea and epilepsy. As a local astringent, it is used in the form of collyrium in ophthalmia, and of an injection in gonorrhœa. Dose.—As an emetic, ℈ j.; to produce its other effects, from gr. i to gr. v.

Zinci Oxydum—*Oxide of Zinc.*—This is used chiefly as a desiccating local application in the form of powder dusted on the part, or in the form of ointment.

Zinci Carbonas.—The impure carbonate of zinc is called calamine. Its uses are the same as those of the oxide. *Ceratum Calaminæ* is an useful desiccating application.

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# ELEMENTARY PRINCIPLES OF MEDICINE.



The premature death which awaits so large a portion of the human race is in a great measure owing to disease; and Medicine is that science which determines the existence and nature, as well as the means of preventing and of curing this class of physical evils.

The causes of disease are of two descriptions, or general and specific. The *general* causes are mechanical or chemical injuries, atmospheric vicissitudes, errors in diet, and powerful moral impressions; and, out of a total of 338,979 deaths in England and Wales, in 1841, the number of persons who died from these causes was 273,636. The *specific* causes are morbid poisons, as that of small-pox, of typhus fever, of measles, of scarlatina, or other contagion; and the number of deaths which resulted from these causes, in 1841, in England and Wales, amounted to 65,343. As the diseases arising from these two different classes of causes are entirely opposed, both in their laws and treatment, it is intended to form them into two great divisions, or into diseases arising from general causes and into diseases arising from specific causes, and to make these the basis of the arrangement of the present treatise. The diseases arising from general causes, being far greater in number and much less complex in their phenomena than those depending on morbid poisons, are entitled to be first considered.

### Of the Diseases arising from General Causes.

The number of diseases arising from the action of general causes appears to be immense; but, on a careful analysis, they resolve themselves into two great orders, or into diseases of function, and into diseases of structure (*morbi organici et simplices*), each embracing a small number of classes. The diseases of function, for instance, embrace the neuroses, hæmorrhages, and dropsies; while inflammation, tubercle, cancer, melanosis, hypertrophy, and atrophy, are the subordinate classes of the diseases of structure. It is proposed to treat of the various species of disease comprised in each class under the head of the particular class to which they belong, prefacing each order and each class with a short outline of its most general laws.

### Of the Diseases of Function.

The diseases of function embrace all those diseases in which the action, the secretion, or the sensation of a part is impaired, without any primary alteration of structure of the organ or tissue affected. Thus, mania, catalepsy, neuralgia, anæsthesia, and palsy, are neuroses of the brain or other portion of the nervous system. Colic, vomiting, diarrhœa, and constipation, are neuroses of the alimentary canal; and so on of other parts. Hæmorrhage, or the effusion of blood, and dropsies, or an effusion of water into the shut cavities of the body, as that of the head, chest, or abdomen, are other instances of functional disease. These two latter classes, however, are so extremely well marked in their phenomena, in whatever part of the body they may occur, that they seem to form each a distinct family; and, consequently, it appears more proper to treat each of them under a separate head.

No science can be understood without some reference to its elementary principles; and three systems have prevailed at different times to explain disease, or vitalism, solidism and humoralism. It seems probable, however, we must adopt the essential parts of all three systems in a sound philosophy of Medicine. Vitalism, for instance, supposes that a morbid state of the vital principle is the cause of disease. This may be questionable; but it is certain that this great principle differs, or has a different force, in childhood, in manhood, and in old age; and also that this force varies, not only at different periods of life, but in different seasons, and even in the same day and in the same hour, in the same person. Disease, therefore, can hardly be understood without taking this element into consideration; and the different phases and force of the vital principle, and the different modifications impressed upon it by social position, necessarily form the most leading feature in what are termed the *predisposing causes*, or the different degrees of liability of persons of different sex, age, profession, or habits, to fall into a given disease.

Besides a given state of the vital principle, a healthy condition of the solids and fluids (the *excitor* and *excited* forces of the body) is equally essential to health. Let us, for instance, divide the sciatic nerve, and all the parts below the division will have lost not only all sensation, but all power of motion; or if we suppose the divided nerve to supply an organ of secretion, that function is also destroyed. Thus, a division of the gastric branch of the eighth pair destroys digestion, while a similar operation on the pulmonary branches causes the animal shortly to die asphyxiated. It is equally demonstrable that any alteration in the proportions or physical properties of the blood, by modifying or rendering morbid one of the great exciting forces of nervous action, is equally a cause of disease. Thus, on injecting a quantity of water into the veins of an animal it falls into dropsy; the abstraction of a portion of fibrine causes inflammation; while the loss of any considerable portion of the red globules is well known to produce most marked debility. It seems determined, therefore, that any departure from a healthy state of the solids or fluids is equally the cause of disease; and hence the necessity of admitting the leading features of solidism and of humoralism, as well as of vitalism, as fundamental principles of Medicine. It will now, consequently, be necessary to point to a few of the more striking facts connected with these theories.

In the examples which have been given, demonstrating the influence of the solids in the production of disease, the nerve has been supposed to have suffered considerable mechanical injury; but it seems probable that the slightest change in the action of the nerve is sufficient greatly to modify the action as well as the



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secretion of the organ or part it supplies. Now the probable mode of action of a nerve is as follows:—

Anatomy has shown that the brain and nerves are fibrous; and a fibrous structure almost of necessity implies action or contraction. But, independent of this argument, there are many beautiful phenomena, especially of sight, which seem to prove that vision and sensation generally result from a physical action or contraction of the nerves, whether of the eye or other organ. Thus, if we look steadily at a target composed of concentric circles of various colours, placed in a strong light, till the sight is somewhat fatigued, and then close the eyes, shaded by the hand placed at about an inch distance, we shall see, says Darwin, the most beautiful circles that imagination can conceive, and which are most resembled when a drop or two of oil is poured on a still lake on a fine day. These circular irides of colour, however, are not only different from those of the target, but are perpetually changing till the eye recovers its usual passive state. These adventitious colours are called the reverse, or supplemental colours. This and similar facts show that vision is not owing to the mechanical impulse of light, or to its chemical combination with the nerves of the retina; for in those cases the spectra formed on the eye would remain of the same colour, only growing fainter and fainter, till they at last disappeared altogether. The probable explanation, therefore, of these phenomena seems to be, that the retina is composed of many sets of nervous fibres, and that when the set whose contractions, for instance, cause the sensation of red is fatigued, it is relieved by the action of an antagonist set whose contractions cause the sensation of green, in the same manner as we relieve the muscles of the arm by changing its position and bringing a different set of muscles into action. Another circumstance, also, which seems to demonstrate that the contraction of the nerves constitutes vision, is, if we press the ball of the eye at its external angle a luminous appearance is observed; while, if the eye be struck a smart blow, we all know flashes of fire are perceived. Now, the sensation of fire thus produced is entirely the result of mechanical causes, light or other natural stimulant being altogether absent. It follows, then, that vision is produced by contractions of the fibres of the optic nerve; and this mode of action, proved to be true of the sense of sight, may be equally demonstrated of the nerves of the other senses, and also of those of the different organs of secretion. It results, therefore, if a healthy action of the nerves (the great moving and secreting powers of the body) be essential to health, that every morbid action of the nerve must be a cause of disease.

The contraction of a nerve, however, although it may account for sensation and secretion, is hardly sufficient to explain the great power imparted to and exercised by the muscles; for if we consider how soft and tender and little coherent the brain and nervous fibres are, and also how easily the muscular fibre is torn after death, something more is wanting than mere muscular contraction to explain the infinitely greater power which the muscular fibre is capable of exciting during life than after death. Sir Isaac Newton was of opinion that the cohesion of bodies depends on the presence of elastic fluids; and this opinion is strengthened, if not completely established, by modern discoveries, for a continued stream of electric fluid will enable a magnet to support a mass of iron, of any weight, for an almost indefinite time. It seems probable, therefore, that nervous contraction is followed by the extrication of a fluid which is the cause of vital cohesion of parts, and of the wonderful force which the muscles exert in moving and raising bodies.

It is singular that the electric fluid, so powerful an agent in producing cohesion of inanimate substances, is also the great agent of chemical composition and of decomposition; and likewise that this fluid is evolved by mere change of motion in the particles of matter. It seems highly probable, therefore, from analogy, that a nervous fluid is extricated in like manner by a molecular motion or contraction of the nerves, and that this fluid is the cause, not only of nervous and muscular cohesion, but is also the great agent of the vital compositions and decompositions which are incessantly going on in every part of the body. Again, when we observe that heat is given off by most inorganic substances after a smart blow, which approximates their particles, we may almost infer that nervous contraction may be one of the means which nature employs to regulate the temperature of the body.

If the theory of a nervous contraction, followed by the extrication of a nervous fluid, be established, the one may be taken as the measure of the other, and the term "nervous sensibility" may be used to express their conjoint effect. This nervous sensibility, it would appear, then, in health, is accumulated by repose and exhausted by action; so that, at times, it may be considerably in excess or in defect. If, for instance, we sit in the dark, the sensibility of the retina is so greatly increased that the eye is actually pained by the admission of a strong light. On the contrary, if we look at the sun, the sensibility of the retina is so absolutely exhausted by the intensity of its rays, that for a time we are blinded to every other object. This property of accumulation and of exhaustion of nervous sensibility is often extremely sudden, or otherwise exists in a most marked degree in disease. Thus, nothing is frequently more unexpected in its attack than a paroxysm of wild insanity, of epilepsy, of hysteria, or of tetanus; while fainting, or the last stages of fever, are familiar examples of collapse, and of the rapidity with which the nervous energy is exhausted.

The hypothesis of a nervous fluid seems to lead to the inference that this elementary principle may be rapidly communicated from one part to another. In health, the action of the brain, in determining a greater quantity of nervous fluid to a particular part, is quite remarkable. Let a black spot, for instance, about the size of a tadpole, be made on a sheet of white paper; that spot, if looked at attentively, will be seen in a few seconds surrounded by an areola of light; a circumstance which can only arise from the retina being rendered more sensible by the increased quantity of nervous energy communicated to it from the brain by the power of attention. In like manner, it is well known that the times of the action of the bowels, the times of eating, and so on of the other functions, may in a considerable degree be accelerated or retarded in proportion as we direct our attention towards those purposes. It is this power of the brain over distant parts which renders the nervous and hypochondriacal person so prone to exacerbations and remissions; for, by constantly brooding over his complaint, a flood of cerebral or nervous energy is directed to the diseased part, and all its morbid sensibilities are immediately

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Elementary Principles of Medicine.

aroused. If we pursue this subject further, it will be easy to show that a powerful action of any one part may readily exhaust the whole system, terminating, perhaps, in almost sudden death. A person, for instance, has strangulated hernia, or a small ulcer of the intestine, the part is not vital, nor the pain great, yet in a few hours the patient lies a corpse.

It would be extremely difficult to exhaust the interesting subject of the action of the solids; but there are two points which it is essential to lay before the reader, as they instance remarkable laws of the neuroses. The first is, that sensation, though almost constantly *passive*, and in health only brought into action when some external agent is present capable of acting upon the nerve, yet is in some instances *active*, or exists when no external agent having any affinity for the nerve is present. Thus, we are often sensible of tastes in our mouths, although we have not eaten the particular substance, perhaps, for some months. In like manner, in insanity, the patient often hears and sees persons and things which have no real existence. Another familiar example of active sensation is, that persons who have lost a limb (as the leg), are often sensible of painful or agreeable sensations, which they refer to the foot, although that part has perhaps been long removed. In all these cases the sensation is evidently active, the nerve taking on those actions by which such sensations were accustomed to be transmitted to the brain. It is, perhaps, owing to this law that a part, having been once diseased, readily runs into the same morbid state, not only when the exciting cause is present, but also when it is absent.

The next remarkable law is, that sensation is not, as is generally imagined, instantaneous; but, like every other function, is performed in certain times. The sensation of sight, for instance, is not instantaneous, for we many times in an hour cover our eyes with our eye-lids without perceiving it, so that the perception of light is not changed for that of darkness in so short a time as the twinkling of an eye. On the continent it has been remarked, that different astronomers observing the passage of a star over the thread of a micrometer by the same clock have varied a third, a half, and even a whole second as to time—a discrepancy, says Nicolai, which can only be accounted for on the supposition of a difference of time in the transmission of the image of the star from the eye to the brain, and also of the sound of the clock from the ear to the same organ.

In disease, the times of the action of the brain are often greatly increased or diminished. In idiotcy, and other forms of insanity, and also after many other severe disorders, the apprehension of the patient is often distressingly slow, while in acute cases the patient will hardly sleep day or night for many weeks together from incessant activity of mind. Again, if we look to the other functions of life, as to defæcation or to digestion, we shall find that the organs on which they depend act only at certain times, long intervals of repose being necessary to renew their power after action. The stomach, for example, in the adult, can only digest three or four times a day, for if pressed beyond a given point food is loathed. In bulimia the appetite can hardly be satiated, while in fever the patient hardly digests anything for many days. The action of the bowels, also, instead of taking place every twenty-four hours, may be incessant, or it may be deferred for several days or even weeks. The law of healthy animal functions then is to remit; and when the natural times are disturbed, disease is the consequence. It is this tendency of diseased actions to remit which so often occasions a difficulty in determining whether the recovery of the patient is owing to medicine or to a natural subsidence of the disease, and it is to this cause we must attribute the endless "nostrums" which disgrace the practice of physic.

Such is the probable action and a few of the laws of the nerves in the neuroses. The few facts relating to the alterations of the blood in this class of disease with which we are acquainted are as follows:—Andral supposes the mean quantity of fibrine in healthy blood to be 3 parts in a thousand; of red globules to be 127; while of the solid contents of the serum, 71 parts are albumen and about 9 parts are free alkali, or other saline substances. Now if we take plethora and anemia to be the extreme points of the constitution in the neuroses, we shall find the natural and healthy proportions of the blood sensibly altered in these states. Thus, in thirty-one cases of well marked plethora, Andral found the proportions of fibrine diminished to 2·7 instead of 3, while the mean of the red globules was as 141 instead of 127. On the contrary, in sixteen slight cases of anemia the red globules were reduced from 127 to 109, while in twenty-four well marked cases the mean was only 65, and in one case they had fallen as low as 28. Again, the quantity of fibrine in the sixteen slight cases was natural, or as 3; while in the twenty-four well marked cases it was increased, or as 3·3. In general, then, in the neuroses the characteristic of the plethoric extreme of the blood is a less quantity of water and of fibrine, and an increased quantity of red globules; while in the anemic extreme the water and fibrine are increased, while the red globules, and probably also the albumen, are greatly diminished. The blood also in this latter state is sometimes slightly buffed, and the globules smaller than in health.

It is singular, in the neuroses the opposite extremes of plethora and of anemia are often marked by nearly the same symptoms as tinnitus aurium, vertigo, palpitation, and hysteria. The different states of the constitution, however, distinctly mark these opposite conditions.

Besides the symptoms common to plethora and anemia, Andral conceives he has determined a law peculiar to anemia, or that, when the red globules of the blood are below 80, the *bruit de diable* is constant, and heard in every artery in the body. When they are about 80 this *bruit* is still constant, but is heard only in the carotid arteries. Again, when the quantity of blood globules is above 80 and below 125, the *bruit*, though still heard in the carotids, is not constant but intermits; while above 125 he conceives the *bruit* ceases altogether.

The facts which have been mentioned will, it is hoped, turn the attention of the student, and awaken his curiosity to the great elementary principles of the Neuroses,—a class of disease usually of long duration, without fever, often strikingly formidable in their symptoms, and in many instances the cause of much suffering. They are generally difficult of cure, and it will be seen for the most part aggravated by bleeding, and assuaged by opiates and tonics, but under any circumstances have a strong tendency to recur.

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ORDER I.

OF THE NEUROSES.—CLASS I.

*Of Insanity.*—Esquirol has defined madness to be a cerebral affection, ordinarily chronic, without fever, and characterized by disorders of the intellect, of volition, and of the senses. A moral as well as a pathological definition, however, is necessary of this disease, and in that view it may be defined to be that state of mind which renders a man an irresponsible being, and consequently unfits him for the performance of the social and political duties of life. The amount of disease necessary to constitute this state must often rest with a jury; for every faculty of the mind may be diseased, as the memory, the judgment, the imagination, and the power of associating ideas, yet the party may continue to be a most useful and even valuable member of the commonwealth.

The history of insanity shows that it is of very early origin. Saul was unquestionably insane; and so familiar does this disease appear to have been among the Jews, that David, to escape from Achish, king of Gath, feigned himself mad: "and he changed his behaviour before them, and feigned himself mad, and scrabbled on the doors of the gate, and let his spittle fall down his beard. Then Achish said unto his servants, 'You see the man is mad.'" The insanity of Hercules, of Ajax, of Medea, and of Orestes, must have been traditional before it became the subject of poetry, and shows that the disease was common even in the fabulous ages of the Grecian annals. In modern times it is a disease unhappily of frequent occurrence, and has, though perhaps erroneously, been supposed to be extended in proportion to the degree of civilization. The numbers that died from this complaint in England and Wales, in the year 1839, amounted, however, according to the Registrar-General's Report, to only 424, or 226 males and 198 females.

*Remote Cause.*—The remote causes of insanity are moral and physical. Of 5653 patients principally admitted into the different hospitals of France, Italy, and Belgium, 558 arose either from falls or blows on the head, from the abuse of mercury, or other physical causes not determined. The other 5095 cases all arose from moral causes, as religion, crossed in love, jealousy, family disputes, reverses of fortune, wounded pride, disappointed ambition, anger, fright, arbitrary detention, excess of study, libertinage, and drunkenness.

The action of moral causes in producing insanity is so striking that the passing events of the day often give the peculiar characteristic of the disease. When magic and witchcraft were believed in, Europe was overrun with persons who supposed themselves possessed by the devil. On the death of the king of France and his unfortunate family, the hospitals swarmed with dauphins destined to succeed him on the throne. The trial of the Duc d'Enghien made many insane impersonators of that illustrious person; and when the Pope was at Paris, that singular event caused many religious monomaniacs—a form of Insanity, says Esquirol, which shortly after disappeared.

*Predisposing Causes.*—The principal predisposing causes are age, sex, hereditary descent, and disease.

*Age.*—Infancy is nearly exempted from madness, and so also is childhood, except in cases of congenital idiotism. Esquirol, however, gives the case of a child between five and ten years old whose monomania lay in attempting to destroy both her father and mother. Insanity, however, as a general principle, seldom breaks out till after puberty, and when the passions are fully developed. Leuret gives the following table of the ages of 11,687 insane patients.

| | |
|---|---|
| Under 20 | 1,007 |
| From 21 to 30 | 2,541 |
| ,, 31 to 40 | 3,438 |
| ,, 41 to 50 | 2,293 |
| ,, 51 to 60 | 1,185 |
| ,, 61 to 70 | 819 |
| ,, 71 to 80 | 364 |
| Above 80 | 40 |
| | 11,687 |

*Sex.*—It has been much disputed which sex is most liable to insanity; but Esquirol, from returns obtained from the different insane establishments of London and Paris, considers the numbers to be nearly equal, the number of males attacked being 6335, and of females 6892,—a result which is remarkable, considering the influence which menstruation, pregnancy, and suckling have in the production of this disease, and which Esquirol estimates as accounting for the insanity of one-sixth of the whole number of women attacked. As an approximation to the influence of social position on the patients, 44 women were unmarried, 80 married, and 20 were widows. Of the males 61 were unmarried, 123 married, and 8 widowers; which shows a larger proportion of insanity among the unmarried than among the married population in proportion to their respective numbers.

It has been thought, also, that the maniac was more particularly affected at the full of the moon; but Esquirol thinks the exacerbation attributable merely to the light, for when that is excluded the patients are as tranquil as at other times.

*Hereditary.*—The testimony of almost universal experience establishes the fact of a very general hereditary transmission of insanity. This is remarkably instanced among the Catholics and Quakers of England, and also among the high nobility of France, who almost in every instance intermarry, and are allied by blood to each other, inculcating a sad lesson to those parents who consult, in the marriage of their children, the interest rather than the health of their descendants. This hereditary tendency to insanity in the aristocracy is greatly insisted on by Esquirol, who states that out of 321 pauper female lunatics, only 105, or one-third nearly, were ascertained to belong to families in which insanity had previously existed; while out of 264 females of the higher classes, 150, or more than one-half, were thus connected. In general, children born before the insanity of their parents are less liable to this disease than those born after the attack; also children born of parents diseased in one line are less liable to it than parents diseased in both lines. The condition of the mother also during gestation has often a striking effect on the mental health of her future offspring; for Esquirol observed that during the French revolution many pregnant ladies whose minds were kept constantly in a state of alarm and anxiety during that epoch, brought forth children which, in their infancy, were subject to spasmodic, convulsive, or other nervous diseases; and in their youth either to madness, imbecility, or dementia, and almost without an exciting cause.

Certain diseases also are powerful predisposing or even exciting causes of insanity, as epilepsy, which gives rise to a large number of the most incurable cases

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of madness. Insanity also often alternates with phthisis—the one disease becoming latent in proportion as the other becomes active. Derangement of function, or structure of the uterus, is also a powerful predisposing cause. Many persons also become deranged after severe fevers; while Foville states that five-sixths of those he examined had more or less disease of the heart, showing the powerful effects of intemperance and of strong passions in the production of this mental affection.

*Pathology.*—The cranium of the insane patient is occasionally found extremely thin, and occasionally greatly thickened; but except in a few cases, especially in idiots, its conformation and size is natural. On opening the cranium, all authors, whether English, French, German, or Italian, are agreed that in a given number of cases, however severe the malady may have been, not a trace of disease, either of the brain or its membranes, is to be met with. The proportion, says Calmiel, may be small (eight times in seventy-five), but still it is enough to prove that insanity is merely a functional disease of the brain, and also to lead to the inference that the lesions of that organ are, in many cases, the consequence of the high excitement and violent exertions of the patient rather than the causes of disease.

When any lesion exists, it is principally slight inflammation of the arachnoid and pia mater, with effusion into their cavity, generally of serum, or of serum with points of lymph, and less commonly of a gelatiniform substance. These lesions are more frequently found at the anterior and superior portions than at the base of the brain. The lesions next in frequency are thickening and opacity of the arachnoid, with effusion of serum in large quantities into the ventricles, sometimes doubling or trebling their capacity. The dura mater is also strongly adherent to the cranial bones.

The substance of the brain is generally healthy, but in acute cases sometimes strongly marked by many puncta cruenta. Again, often on removing the arachnoid, a small portion of the corticle substance, strongly injected, is detached with it. In many cases the brain is softer than natural; and in a very few cases so loaded with serum that Leuret has been enabled to express that fluid from it in considerable abundance. In a very small number of cases the brain is harder than natural. When the patient has fallen from paralysis, the lesions are similar, but occasionally traces of apoplectic effusion have been found.

Such have been the lesions commonly observed in insanity; and if it be asked whether they in any degree explain the seat of the intellectual faculties, they certainly do not, for the same appearances are often observed in patients who have in no degree suffered from insanity. Neither has anything been observed which could in any instance fix or confirm Gall's theory of the localization of the cerebral phenomena, for the same lesion often exists in forms of insanity totally different from each other.

*Symptoms.*—Insanity has many different forms, and is divided into monomania, mania, melancholia, and dementia.

It is hardly possible to understand the nature of insanity without first considering that every sense is liable to be diseased, as light things to feel heavy, small things to seem large, hot things to feel cold; or else that the senses are liable, from the irritation of the brain or other cause, to become *active*, the patient seeing persons or hearing discourses when no such person is present, and no such discourse is related. When he is satisfied by reasoning and the evidence of his other senses that what he hears or sees is an illusion, he is said to labour under an hallucination. When, however, he believes and acts upon them, he is insane. The following are a few instances of hallucination:—

Every sense is liable to the disease of hallucination. Dr. Falconer mentions a case in which cold bodies felt intensely hot to the patient; he could not move but he was burnt. Esquirol mentions a lady who, being recommended a lavement, was desirous of administering it herself. No sooner, however, was the syringe put in her hands, than she threw it away with an expression of horror, stating it felt so heavy that she believed it to be filled with mercury, and that they wanted to make a barometer of her body. A gentleman, whose mind was in every other respect perfect, had constantly the sensation of his mouth being full of pieces of broken glass; while another, curious in his table and choice in his wines, believed everything tasted of porridge. A lady labouring under phthisis quitted lodging after lodging, being everywhere annoyed with the smell of burning charcoal. The sight also is often the seat of hallucination. Dr. O'Connor met with a patient recovering from measles, to whom every object appeared diminished to the smallest possible size. While Baron Larrey mentions another person who saw men as big as giants; and again, another party on recovering from typhus, felt himself to be ten feet high, his bed eight feet from the floor, and the opening of the chimney as large as the arch of a bridge. The celebrated Pascal always believed he saw a precipice on his left hand, and always had a chair placed on that side to prevent his falling into it. The ear, also, the organ that hears "The airy tongues that syllable men's names," is likewise often affected. A gentleman riding by a barracks at evening call never got the sound of the bugle out of his ears for nine months; and everybody knows that Dr. Johnson always entertained a deep impression that, while opening the door of his college chambers, he heard the voice of his mother, then many miles distant, calling him by his name, "Sam! Sam!"

It is remarkable that these hallucinations sometimes occur when the organ is itself destroyed. Esquirol, for example, attended an insane merchant who, though labouring under gutta serena, not only heard persons talking to him, but saw visions that perfectly enchanted him. He had also under his care a Jewess, who was blind, and yet saw things the most strange. She died, when the optic nerve, from its anterior point of decussation till it entered the globe of the eye, was found atrophied, so that the transmission of any exterior impression was impossible. He mentions also two other women absolutely deaf, who had no other delirium than that of hearing every night sundry invisible persons that addressed them.

Such are instances of hallucinations, and the images thus excited are as vivid as those produced by external causes, so that the patient when insane entirely believes the empty and false forms he sees, the ideal sounds he hears, to be real and substantial. Nothing can persuade him of their fallacy; but, like Macbeth, he insists, "If I stand here I saw him." It is only by the occurrence of a temporary hallucination that we can explain the apparition of the ghost of Cæsar to Brutus, promising to meet him at Philippi; or the existence of the familiar

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spirit which conversed with Tasso. It is probable, also, that such hallucinations formed a portion of the psychological phenomena occurring in the cases of Luther, Ignatius Loyala, and Swedenborg. Out of 100 insane persons, 80 at least labour under hallucinations of one, two, or even of all the senses. Thus they are perpetually holding conversations with imaginary beings, seeing ecstatic visions, fighting with enemies ready to destroy them; and in a few instances an angel of light is at one ear, and the angel of darkness at the other. Some, again, smell all the odours of Arabia, while to others everything they eat tastes of human blood, or of raw flesh, or is gritty with arsenic.

In insanity, also, if a part be diseased, the imagination often personifies it, and converts it into some strange reality. Thus, a young woman who suffered from pain in the crown of her head was convinced it was caused by a worm gnawing her brain. An old general, who believed the sun was the cause of all his ills, suffered occasionally pain in the knee; and in one of these paroxysms he seized the pained part with one hand, and striking it with the other cried out, "Ah! rascal, you shall not escape me now!" evidently conceiving his knee to be a thief. There are constantly in the hospitals patients who, suffering pains in the stomach, believe that organ to be filled with serpents or frogs. One man complained his stomach was filled with mice, when a friend advised him to swallow a cat. A woman, for many years a lunatic at Salpêtrière, and who suffered severely from abdominal pains, believed she had a whole regiment of soldiers in her abdomen, and when the pains were severe that they fought with each other. Another woman, called by the patients "Mère de l'Eglise," believed to have in her entrails all the personages of the New Testament, and occasionally those of the whole Bible: when her pains were exasperated, she sometimes cried out, "Je n'y puis plus tenir quand fera t'on la paix de l'Eglise;" and at others she believed the Popes held their councils in her abdomen. This patient died, when the abdominal viscera were found adherent to each other and to the peritoneum; and the same appearances were found in a woman who believed her abdomen was filled with devils.

### Of Monomania.

Having thus stated the nature of hallucinations, we must now proceed to the consideration of insanity, and first of monomania, or that form of the disease in which some one passion or hallucination so entirely possesses the patient as to lead to erroneous and often dangerous conduct. The modes of this affection are endless; some being beset by jealousy; others desperately in love, and sometimes with entirely imaginary objects; others seek their own death or the destruction of other people, or have an uncontrollable desire to commit petty thefts, or to set everything on fire. These varieties are termed kleptomonia, pyromania, autophomania, and erotomania, and so on, according to the passion or imagining of the patient. We shall only be able to give a few of the endless varieties of this disease.

*Hypochondriasis* is a disease of the sense of touch, combined with a morbid imagining, so that the patient believes himself to be strangely metamorphosed, changed into some inanimate thing, or else loses all knowledge of his personal identity; and this form of disease is sometimes combined with other hallucinations. The odd conceptions of the patients under these circumstances are singular enough. Men have imagined themselves to be so much butter or putty, and in the one case to be unable to bear heat for fear of melting, and in the other have forborne to walk lest their legs should be crushed by the weight of their body. One man kept the house imagining he was too large to pass through a given door-way; and when he was pushed through he screamed, affirmed his flesh was torn from his bones, and actually died of fright. One man imagined he was Aldgate pump, that his arm, which was in perpetual motion, was the handle, and bitterly complained that the inhabitants would let him have no rest morning, noon, or night. Another, that he was a seven-shilling piece, and went round to his neighbours hoping, if his wife should bring him to their shops, they would neither take him in payment nor give change for him. A third supposed himself transformed into a beer-barrel rolled along the streets. A fourth, that he was a mutton-chop, and insisted that his wife should take him daily to the butcher to be trimmed. Bishop Warburton speaks of a person who thought himself a goose-pie, a circumstance referred to by Pope in his sketch of Hypochondriasis:—

> "A pipkin there, like Homer's tripod, walks;
> Here sighs a jar, and there a goose-pie talks."

Among other singular forms of hypochondriasis is a belief in an absolute change of sex. Dr. Arnold saw a man who fancied himself in the "family way;" and Esquirol speaks of a male patient who fancied himself a woman, and felt insulted if the slightest liberty was taken with his dress. Some have thought themselves converted, like Nebuchadnezzar, into wild beasts.

In every madhouse there is a last surviving woman; a last man overwhelmed with grief and horror at having out-lived the whole world. Some patients imagine they have no soul, others no body, others that they are absolutely dead. One gentleman approaching his 90th year so far lost his mind that he assembled his family around him and announced to them that he was dead; begged, in communicating the sad intelligence to his absent friends, they would say he went off easily, and expressed himself a little scandalized that the windows were not closed on the occasion, and entreated, as a last favour, for one pinch more out of his favourite snuff-box before he was finally screwed down. Sometimes the supposed deceased party is resuscitated. One man, who received a severe wound at the battle of Austerlitz, believed he had died, and that the body he had now got was not his own, but some machine *mal faite*. Another, that he was guillotined during the French revolution, and had not only lost his own head, but, somehow or other, had got a new one. A third, that his head had been put on his shoulders with the face towards his back; and, lastly, some think they have not only lost their heads, but see them rolling on the ground.

It is seldom, however, that insanity is of so simple and harmless a nature; for more commonly the affections and feelings are subverted, and the persons most dear to us by the ties of relationship become hateful to us; while the mind is more commonly swayed by some destructive passion to effect some object criminal in itself. This state of the feelings may or may not be accompanied by hallucinations. The most extreme form of this description of monomania is androphomania.

*Androphomania.*—Gall gives the case of a man at Vienna, who, after witnessing a public execution, was

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seized with an uncontrollable propensity to kill, although he had a clear consciousness of his situation, expressed the greatest aversion to commit such a crime, shook his head, wrung his hands, and cried out to his friends to keep away. Pinel mentions the case of a persoo who exhibited no other unsoundness of mind than this propensity to murder; so that his wife, notwithstanding his tenderness for her, was near being destroyed, he having only tima to warn har to fly. In the intervals of the paroxysm he expressed every remorse, was disgusted with life, and attempted several times to put an end to his existence. A man was tried at Norwich in 1805 for wounding his wife, and afterwards cutting his own throat, an act so repugnant to his nature that he had been known to tie himself for a week together with ropes to avoid it. Esquirol mentions a woman seized with sudden paroxysms of phrensy to destroy her children, and only saved them by locking the bed-room door and throwing the key away. Metzyer has a similar case of a nurse who requested to be discharged, and on explanation she gave as a reason that every time she undressed the child, struck by the whiteness of its skin, she had an irresistible desire to rip opeo its belly. The deadly purpose with which the monomaniac is seized is accomplished in many different manners and times. Sometimes the murder is long premeditated, and the victim marked out, the patient concealing a knife about his person till an opportunity for effecting his object presents itself, though that period be remote. In other cases the destructive propensity seems the result of a sudden paroxysm. Esquirol gives the case of a man relapsed into insanity, who on returning from the cellar seized a boy on the stairs by the hair, and after a few seconds let him go, saying, "Il ne vaut pas le peine." The next day he sent his wife and sister to the cellar, when he followed and murdered them, saying subsequently in explanation of the act that the cellar seemed to him all on fire. The same authority also mentions the case of a maniac who was sitting round the fire with the other patients, when he suddenly seized a chamber-pot and broke it over his neighbour's head; fortunately he was immediately secured. In a lucid interval he stated he had made this homicidal attempt in consequence of his brothers having appeared to him at that moment crying out "Kill him! kill him!" Other patients, again, are so aware of the approach of the attack, that they entreat to be confined in order that they may not commit the mischief to which they seem irresistibly impelled.

*Autophomania.*—Many monomaniacs, besides being impelled to destroy others, have an irrisistible propensity to destroy themselves. A gentleman who was cheerful, amiable, well-ioformed, and reasoned well on every other subject, made many attempts to commit suicide, giving as his reason "Je m'ennui." This patient, however, had hallucinations both of sight and heariog, imagined he was pursued by the police, and believed even to hear them through the walls of his apartment. Many of these unfortunate persons, not having resolntion to put themselves to death, have killed others in order to suffer a judicial death. One woman, who reasoned, "in order that I may die I must kill some one," attempted to kill both her mother and her children. Some of these tragedies are perfectly terrific. A man in a paroxysm of insanity killed his wife and three children, and would have killed the fourth had it not escaped. After these horrible sacrifices he ripped open his own belly, but the wound not being mortal he again drew out the instrument and pierced himself through and through. This man had enjoyed a good education, and was of a mild character.

It is singular that tha propensity to commit suicide is in some persons so great that many destroy themselves although in possession of fortune, of station, of objects of affection, and apparently in every other respect in the fullest enjoyment of their reason.

The ingenuity of the maniac in providing means for his own destruction is often singular. Some hava thrown themselves under the wheels of a waggon; others have drowned themselves in an incredibly small quantity of water; others have most ingeniously strangled themselves; and others, more closely watched, have swallowed all sorts of heterogeneous articles—pins, needles, bits of broken glass, nails, buckles, and any and every hard substance they could force down their throats. Pinel gives the case of a man who had cut off one of his hands with a hatchet before his arrival at Bicêtre, and afterwards in spite of his bonds attempted to tear the flesh off his thigh with his teeth.

*Pyromania.*—The derangements of feeling and of reason may take other forms than murder; and arson is one of the more common. Some seem impelled to this criminal act by the mere sensual gratification of the excitement, confusion, noise and bustle consequent on tha conflagration. One lad committed repeated acts of arson solely from the delight he took in the blaze, the ringing of the bells, and in the thronging of tha people. At Cambridge, there was a student who was said to hava attempted to set fire three times to his chambers, and probably from this cause. Ofteo, however, it results from a process of reasoning, or from some hallucination of the senses. The destructioo of York Cathedral by Martin was effected under a feeling of divine impulsion, and of his being commissioned to purify the House of the Lord. One maniac set fire to his bed, thinking to escape in the confusion it would cause, and another from believing that, lika Shadrach, Meshach, and Abed-nego, tha flames would respect his person.

*Kleptomania.*—Soma have an irresistible desire to steal. Gall mentions that the first King of Sweden was always stealing trifles. The wifa of a celebrated physician at Leyden never went into a shop without stealing; and a countess at Frankfort had the same propensity. It is related of a physician that his wife was always obliged to examine his pockets in the evening, to restore the things she found there, for ha always took something else as well as his fee.

Esquirol gives the case of a lady of an exactly opposite character. Her insanity consisted in a ceaseless dread of appropriating what did not belong to her; she therefore combed her hair an endless number of times in the day, examined her dress minutaly every time she put it on or took it off, felt in her shoes, turned up the chairs, looked under her plate, and thus consumed many hours in the day in endless cares, lest something of value might have adhered to her dress. Such are some of the forms of this wonderful malady, whose varieties are endless. Tha most common are theomania, chrysomania, doxomania, demonomania, erotomaoia. Thus, some govern tha sun, the moon, and the weather; others are savans, distinguished by their discoveries or inventions; others poets or orators, whose discoveries we must listen to under pain of their displeasure; others are kings or emperors, commanding



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the universe, and giving protection and dignities to those who surround them; others are submitted to the gentler sway of love, and believe themselves to sojourn among the sylphides and houris; others are gods or prophets in commonication with heaven, and the immediate agents of some Divine commission; while others are the separate or conjoined persons of the Holy Trinity.

*Mania, Melancholia, and Dementia* are forms in which the powers of the mind are more generally overthrown, and the senses more commonly affected by hallucinations. In many instances the association of ideas is either so destroyed that the patient is in a state of complete delirium, or else the judgment is erroneous, the memory impaired, and the affections perverted.

It is seldom in mania that the patient, as in monomania, is only insane on one subject. His mind, says Esquirol, is a perfect chaos; all is violence, effort, perturbation, and disorder. He confounds time and space, associates persons and things the most unnatural, creates images the most unreal, and lives isolated in feelings and reasoning from all the rest of the world; his actions also are often wicked; he hates all that he loved, and wishes to overthrow and to destroy everything. The female lunatic, also, perhaps in health the model of candour and virtue, gentle and modest, an affectionate daughter, a devoted wife, and a good mother, becomes in this disease bold and furious, exposes her person unmoved to the gaze of every eye, is blasphemous and obscene, respects no law either of decency or humanity, and threatens her father, strikes her husband, or perhaps murders her children.

The following case is detailed by Esquirol as one of the most general examples of melancholia. A young woman, aged twenty-three years, lived in the country, but had been frightened by some soldiers. For four years afterwards this young person had scarcely been heard to utter a word, and the few she did utter seemed expressive of the terror she was still possessed with. At first she obstinately refused to quit her bed or to eat, but when obliged to get up she went and seated herself on the same bench, and always maintained the same attitude, her head being inclined to the left side, her arms crossed and resting on her knees, and her eyes fixed on the ground, and in this position she remained the whole day. She never asked for food, and it was always necessary to bring it to her and to press her to eat, but still in eating she preserved the same posture, except that she used her right hand. At no time did she ever answer any question. It was necessary to tell her to go to bed; when she undressed, rolled herself up like a ball, and then buried herself under the clothes.

Of *Dementia*, the following may be taken as a specimen. A merchant, after some losses in trade, became perverted in his affections, neglected his business, and refused to eat, for fear of being poisoned, and, indeed, committed all sorts of excesses. This state of excitement was followed by a state of depression, during which he stood by his bedside, his head bent forward, his arms hanging by his side, his eye vacant and fixed, and his countenance unchangeable. This was followed by another paroxysm of excitement, in which he spoke incessantly; abused his family; walked with a rapid step; overthrew all in his way—laughed—stopped—heard and saw his enemies day and night, and especially his mother, who reproached him. The stage of depression again came on; he slavered from the mouth and nose; his urine was passed involuntarily; he refused to eat or drink, or to undress himself, and when placed in bed, lay all night in the position he was first placed in; kept an absolute silence, and at length fell into a state of stupor, from which nothing could rouse him.

Almost all persons suffering from dementia have a *tic*. Some walk incessantly, seeking something not to be found, while others can scarcely drag their legs after them; others walk round and round eternally in the space of a few feet; while others lie rolled up in bed, or extended on the ground. Some write incessantly, but the words or sentences have rarely any connexion or meaning; others talk incessantly, but incoherently, beginning a sentence without being able to finish it; or so completely is the association of names with things lost, that they utter nothing but what Hamlet would call "words! words!" one will strike his hands day and night, while his neighbour will balance his body in one position with a most tiring monotony of movement; another will weep and laugh, whistle, dance, and sing during the whole day; others, again, dress themselves in all sorts of whimsical manners; while others will display a few rusty nails or common pebbles as the riches of the universe. The gradations of this form of madness are, first, a chaotic state of the faculties; secondly, the loss of all sense of propriety; and, lastly, the entire oblivion, or nearly so, of every spark of intelligence.

In dementia the patients are extremely liable to become paralytic; and an affection of the tongue, denoted by a thickness of speech, is the first symptom. After a time, the speech is more manifestly affected, and is followed by a loss of power in the limbs of one side, more marked in the lower extremity, so that their step is feeble and straggling. In the last stage they are completely paralytic, and only able to utter a few unintelligible sounds. Of 120 paralytic cases of dementia 13 were in the first stage, 52 in the second, and 55 in the third stage of this calamity.

Looking to insanity generally, it is seldom that the ideal character assumed by the patient is well sustained; more commonly it is little more than the name. In a few cases, however, it is well supported, and the prophet assumes a tone, energy, and attitude suited to the envoy of the Almighty, and the emperor the majestic step and deportment corresponding to his fantastic regal state. In these instances he almost always sees visions, or is visited by invisible interlocutors, to whose dictates he generally becomes fatally obedient.

Whatever form insanity may assume, like other diseases it may be divided into three stages. The first stage may be sudden in its attack, sometimes almost instantaneous, but more commonly it is marked by a short prelude of an indefinable aberration from health both of body and mind; for the patient, besides being out of health, is easily excited, is headstrong, and ready to commit every sort of extravagance. In the second stage the disease is formed; while in the third stage the patient, if he recovers, becomes more docile, more natural in his affections, sleeps better, and takes more food; or else the disease may become inveterate, incurable; or epilepsy, palsy, or other phenomena may unexpectedly terminate his existence.

The attack of insanity may last many weeks, many months, or many years, but in most cases it has a tendency to remit; and hence authors have divided this disease into continued, remittent, and intermittent.

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The remittent form differs from the continued by the fact of remissions more or less marked. Thus many patients are violent by day, yet are calm and tranquil at night; while others, on the contrary, are tranquil by day, but are sleepless and violent at night. Sometimes the remission is only every second day, when it takes place with great regularity. This tendency to remit has been remarked by Shakespear:—

> "This is mere madness;
> And thus awhile the fit will work on him;
> Anon, as patient as the female dove
> When that her golden couplets are disclos'd,
> His silence will sit drooping."

Again, the paroxysm of insanity is sometimes so regular as to assume an *intermittent* type, occurring every week, every month, every three months, twice a-year, or every one, two, three, or four years, often without any other known cause than the return of the period.

*Diagnosis.*—One of the great difficulties of diagnosis in this disease is to distinguish monomania from sanity; for, with the exception of some given morbid delusions, the patient may be rational on all other subjects, and in some instances even the powers of his mind are increased. One celebrated instance of this kind occurred to the late Lord Erskine. The lunatic had indicted a most affectionate brother, together with the keeper of the madhouse, for false imprisonment. He was placed in the witness box, and Lord Erskine, not instructed in what his lunacy consisted, consumed the whole day in fruitless attempts to expose his infirmity. At length Dr. Sims came into court, and suggested to the learned counsel that the patient believed himself to be the Lord and Saviour of mankind. Lord Erskine then addressed him in that character, and lamented the indecency of his ignorant examination, when the patient expressed his forgiveness, and with the utmost gravity and emphasis, in the face of the whole court, said—"I am the Christ!" In a similar case, tried before Lord Mansfield, the patient evaded the questions of the court the whole day, till Dr. Batty arriving, asked him what had become of the princess with whom he corresponded in cherry-juice. Instantly the man forgot himself, and said it was true he had been confined in a castle, where, for want of pen and ink, he had written his letters in cherry-juice, and thrown them into the stream below, and that the princess had received them in a boat. These answers of course immediately terminated the cases. It is plain, therefore, that we shall often be foiled in examining an insane patient unless we make some previous inquiry as to the points on which the party is deranged.

*Prognosis.*—As a general rule, the younger the patient the greater the chances of recovery; but above the age of fifty few are cured. Of those that recover, the exciting cause often greatly influences the result; thus most recover when it proceeds from drunkenness, provided the patient can be restrained from drinking; and also if it arises from slight moral or physical causes. When, however, the shock is severe, the recovery is less certain, and if combined with epilepsy or any organic affection of the brain, recovery is almost impossible. The form of the disease also greatly influences the result, for when the patient suffers from hallucination, the chances of recovery are much diminished. Taking insanity generally, the maniac has been cured in the ratio of 1 in 2·05; the monomaniac as 1 in 1·78; the melancholic patient as 1 to 2·33; and the stupid as 1 in 3·33. If, when labouring under dementia, the patient be seized with palsy, Esquirol knows of no instance of his surviving a twelvemonth after the first symptom, or the affection of the speech.

The mortality among the insane appears to be infinitely greater than that of the population generally, and on a calculation of nine years at Bicêtre, an hospital containing 1200 patients, the annual deaths were as 1 in 6·7 cases. The largest mortality is from dementia, the least from monomania; in the latter, indeed, where there is no tendency to suicide, the duration of life is little abridged, so that premature death is almost in all cases owing to accidental causes.

*Treatment.*—The treatment of insanity resolves itself into the medical, the moral, and the dietetic treatment.

All the best and most candid practitioners admit that medicine has very little direct action on the brain, so as favourably to influence the course of the disease; but indirectly, however, by regulating the different actions and secretions of the other organs, and thus improving the general health, the happiest results are often obtained. Thus, when the bowels are constipated, the mode of treatment is determined by the state of the tongue; or, supposing it to be white and coated, the sulphate of magnesia, or other neutral salt, combined with tinct. hyoscyami in the proportion of ʒj. of the former to ♏xv. to ♏xxx. of the latter out of camphor mixture is among the best remedies; but any other purgative or opiate, in corresponding proportions, may perhaps be equally serviceable. If, on the contrary, the tongue be clean, the cathartic should be given with some slight bitter, as the infusi aurantii or the infusi gentianæ comp. In some cases the bowels are not only exceedingly obstinate, but the patient is greatly averse to all medicines, and now one or two drops of croton oil placed on the tongue produces free evacuations, and prevents the necessity of employing violence.

The mild purgative treatment formed the basis of cure in the school of Pinel and of Esquirol, and they usually combined it, in cases of violence, with the application of cold to the head and of warmth to the lower parts of the body, such as placing the patient in the warm bath and giving him the cold douche. The further treatment consists in restoring any other functions that may be in defect or in excess, as the functions of the uterus in the female, and of the liver or heart in both sexes, and by the usual remedies applicable for those purposes.

Most practitioners are agreed, as a general principle, that bleeding ought to be avoided. The continental physicians are entirely averse to it, as increasing rather than calming the excitement, and tending to produce organic changes of the brain, rather than to cure or prevent them. In this country it was formerly the custom to bleed the patients in spring and fall; and Crowther states he has bled 150 at a time, and that the blood in every case was free from any inflamed appearance. There was also the absence of all inflammatory character in the blood of 194 patients out of 200 bled by Dr. Haslam. In the present day some difference of opinion prevails as to small but none as to large bleedings. "When loss of blood," says the late Sir William Ellis, "is excessive, the vital power in numerous instances is never recovered, and the patient sinks into a state of fatuity, or dies. Unfortunately, many patients received into public hospitals as recent



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cases, have previously undergone this exhausting process, the constitution has not energy to rally, and there is a much greater mortality among the recent than among the old cases, in proportion to their number and ages. There is a much greater probability of an ultimate cure when nature is left to herself, and the violence of the attack allowed to be expended, than when her powers have been wasted by excessive depletion." The same authority also adds, "As far as my experience extends, I have not seen any advantage arise from the use of blisters upon the head during the paroxysm. They appear rather to create irritation than to allay it, and they prevent by their application the use of cold water or of ice, which has often the most salutary and instantaneous effects." And, again, with respect to opiates, "That medicine which will allay watchfulness in one will not in another, but, on the contrary, increase it. This is particularly the case with opium, which is rarely found admissible in insanity. It more frequently creates heat and general febrile action than sleep." In cases, however, of recent excitement, morphia in considerable doses has been found most beneficial.

The moral treatment is by many supposed to constitute the more principal means in the cure of insanity, and it must be admitted to be a most important adjunct. The first important rule is to remove the patient at once from his family; in slight cases, in order that he may be induced to exercise such command over himself as he possesses; and in severe cases, in order to prevent his doing mischief either to himself or others. In the latter instance, if the patient be excited, it is proper to place him at once in a dark room, and remote from noise, in order that there may be as few objects as possible to rouse and fix his attention.

When it is necessary to confine the patient, an overwhelming force should be procured; for a maniac often believes himself to have supernatural powers, and will often fight against one or two persons, when he will feel it useless to resist three or four. The usual mode of confinement is the strait-waistcoat, or a pair of canvas sleeves joined by a broad shoulder-strap, the part covering the hands being made of stiff leather, to prevent the patient grasping anything, or a pair of leather hand-cuffs. It is sometimes necessary to secure the feet, when a couple of leathern straps, well lined with wool, placed round the ankles, and secured to staples in the bedstead, is all that is necessary. Occasionally, the body must be secured; when a thick quilt should be thrown over the clothes, and fastened by three leathern straps on each side. When the patient is able to sit up, an easy mode of confinement is an arm-chair, each arm being hollowed out and made to open so as to contain an arm of the patient. In this manner each upper extremity, as well as the trunk, can be fastened, while the legs may be secured to a foot-board, which, if perforated with holes, will enable us to apply hot water constantly to the feet.

When intervals of reason are established, the patient should be encouraged to exert all the self-command he possesses, by great kindness and attention, and by sometimes punishing his faults and his follies by slight privations; and when the patient is visibly not doing his best, or is malicious, the cold douche has often excellent effects, and any improvement should be rewarded by increased indulgences. As the convalescence advances, he should be induced to undertake some manual labour, or some office in the household, which, by amusing his mind, and invigorating his health, greatly tends to his restoration. When the circumstances of the patient admit of it, travelling, which embraces change of air and change of scene as well as exercise, is often highly salutary in incipient cases. Much has of late been spoken of the introduction of music and other amusements into asylums. Esquirol, however, who made many experiments of this kind, induced the musical professors of Paris to perform concerts at Salpêtrière, and also took his patients to the theatres, but considered these amusements in every instance to have acted unfavourably. When reason is restored, and the affections again fix themselves on their natural objects, the patient may now be allowed to see his friends, and have his attention directed to the affairs and interests of his family; but it should be remembered that the mind remains weak and enfeebled for some time after apparent recovery, and consequently the patient's restoration to society should be gradual.

*Dietetic Treatment.*—In general the patient requires a light but nourishing diet, with a limited portion of wine. When, however, the head aches, or the tongue is coated and white, neither meat nor poultry should be allowed.

### EPILEPSY

Is a sudden and complete loss of all consciousness, with convulsions.

This disease has been known from the earliest antiquity, and is remarkable as being that malady which, even beyond insanity, was made the foundation of the doctrine of possession by evil spirits both in the Jewish, Grecian, and Roman philosophy. The number of adults that fell from this disease in England and Wales, in 1839, was 1186, of children, 25,408,—making a total of 26,594.

*Remote Cause.*—When epilepsy is the result of a powerful original tendency, it often occurs without any apparent cause, and when the patient is in his best health. The effects of moral causes in its production are so well known that Raphael has introduced into his picture of the Transfiguration, a boy falling into an epileptic fit. Besides moral causes, errors in diet, excess of any kind, blows on the head, every structural or functional disease of the brain, and especially insanity; or any severe disease, as fever or small-pox, are all powerful remote causes. In children, the irritation of teething is the most common cause.

*Predisposing Causes.*—The large number of children that die of this disease has been mentioned; and indeed in France epilepsy is termed "mal des enfans." The next most frequent period of life is puberty; and its frequency, perhaps, as a primary disease, decreases from that time till 50, when it again increases, from the tendency the brain now has to insanity and to structural disease. As epilepsy is common in idiots whose heads are deformed, it has been affirmed we are liable to this disease in proportion as the facial angle approaches to 70°. There are many exceptions, however, to this law, as witness the fine head of Napoleon.

It is supposed that in infancy, and under seven years, it occurs in nearly equal proportions in both sexes. After puberty, when the distinction of sex is marked, some authors contend it is more common in males than females: Dr. Elliotson thinks in the proportion of 27 to 11: Esquirol, however, says, on comparing the number of epileptics at Bicêtre and at Salpêtrière, the number of women attacked was one third greater than of the men.

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It is also a very general opinion that this disease is hereditary.

*Pathology.*—It has been affirmed that in 15 out of 20 cases, in which the brains of epileptic patients have been examined, the structure of that organ has been in every respect healthy. Even when the patient has died during the paroxysm, the brain has in many instances only been found congested. Epilepsy is therefore merely a functional disease, and being a purely functional disease its particular seat is not determined. But although epilepsy may exist without any disease of the brain, or of its membranes, it must be admitted that the brain and its membranes are occasionally found in every state of disease to which those parts are liable. Thus, the membranes may be inflamed, thickened, or ossified, with every form of effusion to which they are liable; or the substance of the brain may be indurated or softened —the seat of abscess, of cancer, of tubercle, or of other structural disease—and of which the epileptic attack is merely a symptom.

*Symptoms.*—Epilepsy has no varieties, but it may be grave or slight. The attack of this disease often occurs without any previous warning; so much so that Georget estimates, that in 95 cases out of 100 there are no premonitory symptoms. Many patients, however, on the approach of the fit have vertigo or headache; some swelling of the veins, or beating of the arteries of the head; while others have ocular spectra or affections of the other senses.

Dr. Gregory used to mention, in his lectures, the case of an officer whose paroxysm was always preceded by the spectre of an old woman dressed in a blue cloak, who issued, as he imagined, from the corner of the room, and knocked him down with her stick. Dr. Fothergill attended a Quaker who always fancied he saw his garb covered with spangles before he fell into the fit. These ocular spectra are very numerous; but the most common are flashes of light, tadpoles, flies, coloured areolæ around the flame of the candle, black dogs and white horses. Others have hallucinations of the ear, as the ringing of bells, or the roaring of the sea, while others again are annoyed by the smell of disagreeable odours, or by the sensation of unpleasant tastes.

When the sense of touch is the seat of the hallucination, the term "aura epileptica" is used to express it. In these cases the patient has often the sensation of a fluid creeping from the fingers or toes upwards towards the trunk; others feel as though a spider or other insect were crawling over the skin. Dr. Elliotson speaks of a patient that had two auræ, each of which ran along the dorsum of each foot, ascended up the front of the legs and thighs to the trunk, where they broke into five streams, all of which again met at the epigastrium, and, having reached this point, he fell into the fit. These sensations appear to reside in the skin, and not to follow the course of any particular nerve.

Esquirol met with a case, a woman, in which the prodrome was the patient's turning round for a considerable time; and another, in which the party ran with all his might, till at length he fell down, overpowered by the disease.

In the *adult*, whether these warning symptoms be or be not present, the attack usually commences by the patient uttering a cry, losing on the instant all consciousness, and falling down in convulsions, his mouth being covered with foam. The convulsions vary from the most trifling and transitory convulsive movement, to the most frightful, terrific, and long-continued struggles. In mild cases only one limb is convulsed; in others only the face, the lip, or the eye. Esquirol gives the case of a lady whose fits were so slight that although often seized on horseback she never fell off. In a few seconds she was recovered, and resumed the conversation by finishing the sentence she was expressing. In this case, however, the epileptic cry and the convulsed eye denoted the true nature of the attack. One lady, advanced in life, suffered from fits so slight, that she preserved her seat in her chair; so that, except some slight convulsive motions about the mouth, followed by a short sleep, the attack would have passed unnoticed. Attacks so mild often occur many times in the day, last about five minutes, and leave no feeling of ill health behind.

In severe forms of the disease the convulsions are more formidable; the hair stands on end, the forehead is wrinkled, and the brow knit. If the lid be opened, the eye is seen injected, sometimes convulsively agitated, at others in a state of strabismus, and sometimes fixed: more commonly the lid is quivering, half open, showing the white of the lower portion of the conjunctiva. The face is red, or livid and swollen; the teeth generally clenched, and the mouth covered with foam; sometimes, however, the mouth is open, and the tongue thrust forward; and should the masseter muscles now act spasmodically, it may be bitten through, or otherwise much injured, and the foam consequently be mixed with blood. The force with which the jaw closes is so great, that the teeth have been broken and the jaw luxated. The limbs also are violently convulsed, thrown about in every direction, and with such power that it often requires three or four persons to prevent the patient seriously hurting himself. In these convulsions, also, his hands are strongly clenched, and his body often arched backwards, as in opisthotonos; and in this case, on the muscles relaxing, he falls to the ground with great force. While the limbs and trunk are thus powerfully agitated, the muscles of the chest are spasmodically fixed, and hardly admit the act of respiration.

The functions of organic life are not strangers to this scene of tumult and terror. The pulse is generally frequent, sometimes hard and intermittent, and at others scarcely perceptible, although the heart beats strong and tumultuously. The respiration is stertorous; the stomach and bowels troubled with borborygmi; the skin inundated with sweat, while the urine, semen, or fæces, are occasionally emitted. Blood also sometimes flows from the eyes, ears, or nose, frightfully expressive of the violence of the attack.

When the paroxysm has reached its crisis, the muscles relax, the convulsions subside, the respiration becomes more free, the pulse more regular, and the countenance more natural; and at length the patient falls into a heavy sleep, from which he awakes sometimes in good health, but more often shaken, exhausted, and suffering from severe headache, which lasts some hours or some days. In neither case, however, has he the slightest consciousness or remembrance of what has passed. In other instances the termination of one paroxysm is but the beginning of another, and the succession is occasionally so continued that the attack, with short intermissions, may last twenty-four, forty-eight, or even more hours.

When *Children*, from teething or other cause, are seized with epilepsy, the attack is often preceded by a

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spasmodic affection of the larynx, causing the hooping or crowing sound so well known to every practitioner; but it may and often does take place without any warning. In the former case, the child perhaps is in his best health, but on awaking is seized with the characteristic hoop, often accompanied by a spasmodic flexion of the thumb against the palm; or else the fingers are clenched, or the toes bent. These symptoms may occur a varied number of times, till at length, with or without this warning, the eye is seen staring, fixed, or convulsed; the face and extremities pale or livid; the hand clenched, the body rigid, and the head and trunk curved backwards. The fit is now formed; and if we examine the fontanelle, we find it distended and pulsating. These symptoms generally last only a few minutes, when a strong expiration takes place: a fit of crying succeeds, and the child, much exhausted, recovers its consciousness, and, after a short interval, generally falls asleep. These convulsions seldom occur during the early periods of lactation, nor until the period of the child cutting his teeth, nor after three years of age.

The duration of the paroxysm is very various. In children they seldom, as has been stated, last more than a few minutes. In the adult they often do not exceed that period; but in many cases they last half an hour to two hours, while in others the greater part of the day passes before the paroxysm terminates.

It seldom happens that the paroxysm occurs but once. In the mildest case in the child, it is commonly repeated three or four times in the course of the first three or four years of childhood, while in other cases it will occur three or four times in the day; and in severe cases the child is hardly out of one fit before it falls into another, till at length they gradually subside. In the adult, the frequency of the fit varies extremely in different patients. In some instances there is an interval of several years; at others it returns annually, or every six months, or menstrually, weekly, or even daily, while others will have twenty or thirty fits in the course of the same day. The paroxysm, however, returns not only periodically, but also at every irregular interval. The period of the day the attack takes place is also very varied, for it may occur during the day, at night, when asleep, or in the morning, when just awaking.

Such are the laws relating to the paroxysm; but epilepsy is not only frightful from the violence of the symptoms, but also from the serious effects it may produce on the moral character as well as on the physical frame of the unhappy patient. Thus, some fall into the fire and are burnt to death; others into the water, and are drowned; others give themselves a black eye, or other bruise; while, in some cases, a limb has been fractured. Many epileptics have a convulsive action or *tic* of the muscles of the face, or their legs waste and are unable to support the weight of the body. In some instances the leg has been flexed under the thigh, a contraction which has lasted more than a year, while, in others, the patient has become paralytic. A case of this latter description occurred lately in St. Thomas's Hospital, in a woman about 40, who had not only lost entirely the use of one side, but although she retained her voice, and understood what was said to her, she was incapable of uttering an articulate sound.

Aretæus, in describing with his beautiful perspicuity the symptoms of epilepsy, has not neglected to speak of the baneful influence of this disease on the intellect, of the memory being lost, of the imagination being impaired, and of the functions of the brain being, in many patients, so subverted that they fell into incurable insanity. Esquirol gives the cases of 385 epileptics under his care, in the hospital Salpêtrière, and he states that four-fifths were more or less insane. The remaining fifth had preserved their reason, but, he adds, "a reason so broken!"

*Diagnosis.* — Epilepsy is to be distinguished from apoplexy and hysteria. It differs from apoplexy by the violent convulsions which accompany it, and by the foaming at the mouth; and from hysteria by the absence of the rising of the throat, of the screaming, laughing, and crying peculiar to that disorder. It must be admitted, however, that the diagnosis between these diseases is often difficult.

*Prognosis.*—Epileptic convulsions during teething generally subside about the second or third year; children, likewise, first seized between three and four years old, are often cured, or it often subsides at puberty, except when hereditary. Hippocrates imagined that epileptics attacked after puberty are incurable, and this is certainly the fact when epilepsy is conjoined with insanity. Pregnant women attacked with epilepsy are in great danger.

*Treatment.*—The treatment divides itself into what is to be done during the paroxysm, and subsequently during the interval.

The best practitioners are of opinion, when adults are labouring under the paroxysm, that, in general, little can or ought to be done except bringing the patient into fresh air, taking off what may be around the neck, and baring the chest, together with the more imperative duty of preventing the patient doing himself any injury. Bleeding, so often had recourse to, except in parturient women, is rarely found beneficial, and is supposed, in many instances, to prolong the attack. If, however, the paroxysm be greatly prolonged, cold to the head, and opening the temporal artery, may be of some service.

The paroxysm passed, the probable cause should be investigated, and if possible removed; the state of the bowels should be particularly inquired into and regulated, and leeches should be applied to the temples, if the headache be severe. In women, also, the menstruations, if defective or excessive, should be remedied. These few simple rules are of the first importance, not only as removing the immediate inconveniences incident to the attack, but also as a means of prolonging the interval, and, perhaps, preventing its future occurrence. In a few instances, the patient by their adoption is cured; but too commonly the fit returns, and then it must, in candour, be admitted that the pharmacopœia at present furnishes no efficient curative remedy. The most usual analeptics are valerian, iron, zinc, quina, misletoe, musk, opium, assafœtida, mercury, the iodide of potash, camphor, æther, and the preparations of turpentine. The argentum nitratum, once esteemed a specific in this complaint, has not only failed, but, by occasionally staining the rete mucosum of a dingy blue, has often permanently disfigured the patient. Of the long catalogue which has been mentioned, each medicine is, perhaps, useful for a few weeks; but after that period its good effects are, for the most part, lost; so that it would appear to act rather mentally than physically, or through the influence of the imagination than potentially, in removing the cause and altering the action of the brain.

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In cases in which epilepsy is conjoined with insanity, every attempt at the cure of the patient has been painfully unsuccessful. Esquirol states that, at Salpêtrière, he tried, on 339 epileptics, "bleeding" in all its forms, purgatives of all kinds, baths of all temperatures, as well as every kind of vegetable or mineral antispasmodic. But, as the result of his great experience and vast variety of practice, he found that every new remedy suspended the access for about a fortnight, and, in some cases, for one, two, or three months. After these periods, however, it always returned, so that he never saw one case in his hospital practice cured, nor was he more successful in his private practice; for although the paroxysm was often suspended by the confidence inspired by consulting a new physician, yet the remission or suspension was short, and the disease always re-appeared. He concludes that hysteria may have been mistaken for epilepsy, and been cured, but not epilepsy itself.

With respect to local or derivative treatment, as issues, setons, and actual cautery, he states that, when Pariset went to Cadiz to investigate the nature and causes of the yellow fever, raging in 1821 in that town, he was left in charge of Salpêtrière, when he found 20 epileptics treated with two, three, or more moxas on the vertex of the head, which had burnt down to the external table of the skull. These wounds he kept open with great care, but not one patient was cured. In a young epileptic, whose fits were preceded by an "aura" commencing in the great toe, he cauterized that part down to the bone. The aura epileptica disappeared, but the paroxysms became more frequent and more violent.

Although the medical treatment of the adult is so unsatisfactory, yet the treatment of epilepsy occurring in children during teething is almost always successful. The practice, on the child falling into a fit, is immediately to place it in a warm bath, and to pour cold water on its head, to lance its gums, and to throw up an enema. These means generally bring the child to himself; and the after-treatment is to apply a few leeches to the head, to purge it with calomel, either alone or combined with some other cathartic, and to diminish the quantity and quality of its diet. These means are all the case admits of, and they are very generally successful. Bleeding, it should be remembered, should be used with great moderation, for these fits seldom affect the intellect, and have a tendency to subside spontaneously in a very few months. When depletion, however, is carried to excess, the child's health is greatly broken, and the probability is, that the brain is rendered more irritable and the fits more frequent. Slight opiates, by soothing the irritation of the mouth, are useful in every stage of the complaint, and when greatly debilitated some mild tonic treatment may be necessary to restore the little patient.

*Dietetic Treatment.*—In the adult the diet should be light, and the patient live remarkably temperate. The diet of the child should be, if possible, its mother's milk, with or without arrow-root. If above three or four years of age its diet should consist entirely of farinaceous or other vegetable matters.

### Hysteria

Is a nervous disorder, commonly of a paroxysmal character, in which the patient experiences the sensation of a ball rising in the throat, or a feeling of suffocation, which may or may not be followed by convulsions, during which she laughs, cries, screams, and although apparently insensible, yet generally retains much consciousness of what is passing around her.

This disease is mentioned by Hippocrates in his "Natura Muliebrum," by Plato in his "Timæus," and also by Galen. It is likewise treated of in the works of the earliest modern writers on medicine. No death from this disorder is to be found in the reports of the Registrar-general.

*Remote Cause.*—The remote causes of this affection are rather moral than physical; and in a young person predisposed to the disease almost any mental emotion will excite it, as anger, disappointment, jealousy, protracted expectation, the loss of a husband, a friend, or a child; indeed, all that brings the passions into play is a cause of this disease, and many women cannot go to church, or witness a tragic representation, without suffering from their "sex's fits."

*Predisposing Causes.*—This disease almost exclusively attacks females between the ages of 15 and 45, or during the most sexual period of woman's life. The parties most liable are the unmarried, and of these those that labour under amenorrhœa or menorrhagia. The married woman often suffers just after conception, or before partorition, or subsequently from protracted suckling. The barren woman, however, is most liable, and probably from her mind being acted upon by a greater number of exciting causes. Taking classes of women, the higher classes, from their higher living, artificial breeding, and false estimate of life, are greater sufferers than the lower classes.

But although this is a disease almost peculiar to woman, it is not entirely so, but occasionally affects the "nobler sex." Shakespear has made Lear exclaim, when Gloster relates the cause of his being put in the stocks—

> "Oh, how this mother swells up toward my heart!
> *Hysterica passio!*—down, thou climbing sorrow
> Thy element 's below!"

It sometimes also occurs in minds less torn by passions, and of less vigour than Lear's, and is not unusual in men of weak constitution and feminine habits. One remarkable case of this kind occurred some years ago in St. Bartholomew's Hospital, in which the patient, a tailor, when seized with the paroxysm, not only shouted, screamed, hallooed, but actually, by the force of his gluteal muscles, would jump his heavy bedstead into the middle of the ward.

*Pathology.* — It is seldom the patient dies from hysteria, but occasionally women have, in their moments of ungovernable feeling, fallen by their own hands; some by cutting their arms across so deep as to divide the brachial arteries, and others by other means, as hanging or poisoning. Nothing, however, has been discovered, on the most minute examination of the body, to account for this affection. It is, therefore, merely a disease of function, or one of the neuroses.

In speculating on the seat of this affection, the ancients supposed it to be the uterus roaming about the body in search of impregnation. Looking, however, to the excited state of the passions, the general convulsions of the whole body, and the affection of the eighth pair, there seems no doubt its seat must be in that mass whose influence is so universally felt all over the body or the brain.

*Symptoms.*—The forms and degrees of hysteria are

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so numerous that the difficulty of describing this disorder is very great. The modifications of age, temperament, states of nervous sensibility, physical and moral education, and grades of society so influence it that it is only possible to give a most general outline. It is usually divided into three forms: or, first, the globus hystericus without convulsions; secondly, into its paroxysmal form, or the globus hystericus with convulsions; and again, into those irregular and anomalous forms which often manifest themselves during the intervals.

The milder forms are those which terminate without the formation of the paroxysm. They commonly begin with pains in the epigastrium, in the left side, or in some other part of the abdomen; or else the patient is generally nervous, her feelings excited or depressed, and these symptoms having existed for a greater or less length of time, a ball, the "globus hystericus," rises apparently from the lower portion of the abdomen, and proceeds upwards with various convolutions to the stomach, and thence to the throat, causing a sense of suffocation. At this point the slighter forms often stop, but are frequently followed by headache, stiffness of the neck, general weariness, a profuse discharge of a light-coloured limpid urine, and by great flatulence, the patient often becoming almost instantaneously distended with wind.

When hysteria assumes a paroxysmal form or "fit," it may be preceded by the pains and mental feelings which have been described; but not unfrequently the attack is sudden, and often caused by some momentary and transitory occurrence. In these cases the patient bursts out into a fit of immoderate laughter or crying, the globus hystericus then rises, and no sooner reaches the throat than she falls to the ground apparently unconscious, and violently convulsed. The fit is now formed, and, in delicate women, the convulsions are easily controlled, but in the strong and plethoric many persons are necessary to restrain the patient, who writhes her body to and fro, agitates her limbs in various directions, and beats her breast repeatedly, commonly the right, with her arm and hand. During the fit the patient also often knocks her head against the bed or floor, tears her hair, screams, shrieks, laughs, cries or sobs alternately. The respiration is slow, and rendered still more laborious by spasms about the pharynx and glottis, so that the patient often grasps her neck and throat, or rubs or strikes the epigastrium and left side with her hand. During this struggle she often bites her own arms or those of the bystanders, and, if left to herself, will sometimes travel all round the room, by means of the gluteal muscles, on her back. The abdomen is often singularly distended with wind; but, in other cases, the abdominal muscles are tense and irregularly contracted. The pulse is, in some cases, increased by the violence of the exertion, but in others its beat is natural. The veins of the neck are distended, the carotids beating with more than usual violence, and the face is flushed. The temperature of the extremities is often lower at the commencement than natural, so as to cause a momentary shivering; but as the paroxysm forms the heat is usually restored and sometimes increased. The phenomena of the subsidence of the paroxysm are very various; sometimes attended by a flood of tears, a fit of laughter, or by an exclamation; and if this is followed by a great flow of limpid urine, the recovery is generally rapid and complete. In other cases the action of the stomach becomes inverted, so that the attendant, perhaps watching the patient with the tenderest sympathy, receives its whole contents in his face, after which she sinks into a profound sleep. In others, again, the fit only partially passes off, and the patient lies, to a certain extent, sensible of what is passing about her, but jaw-locked, the secretions of urine suspended, unable to talk, and obliged to be fed.

The fit having subsided, the patient lies exhausted and unwilling to be disturbed, and although more or less conscious of what has passed, she wishes to be thought ignorant of all that has taken place. A want of consciousness may exist when the fit assumes a severe or epileptic form, but this is not a common symptom of the pure hysterical convulsion. In some few cases the patient is delirious, and makes the most extraordinary noises, as barking; but this is probably feigned. The duration of the fit is very various, or from a few minutes to two, three, or more hours. These fits readily recur, and no sooner is one ended than the patient often falls into another; and in this manner the whole attack may last twelve, twenty-four, or even forty-eight hours. In general the intervals are much longer, not subject to any general law of recurrence, except they are more common about the period of menstruation.

In the interval the symptoms are extremely anomalous and irregular, and more strange and difficult to describe than even those of the paroxysm. Some have their senses so acutely alive, that although the window and bed-curtains may be drawn, still they are pained with light, and the slightest noise distresses them. In some, again, the sense of touch is so exquisite that they can scarcely bear the weight of the bed-clothes; and to others odours are similarly intolerable; so that to—

> "Die of a rose, in aromatic pain,"

is not the mere feigning of the poet's imagination. Besides this extreme acuteness of the senses, others suffer pains under the mammæ, lumbar pains, pains in the hip-joint, headache fixed to one spot, and termed clavus hystericus—palpitation. Pain in the region of the spine is also frequent, and often so intense and so exquisitely increased by pressure that it has often been mistaken for ulceration of the intervertebral cartilages; and Sir B. Brodie has seen numerous instances of young ladies condemned to the horizontal posture, and to the torture of issues and setons for successive years, whom air, exercise, and cheerful occupation would have cured in a few weeks.

As to painful affections of the joints, the same high authority states, that at least four-fifths of the females among the higher classes, who are supposed to labour under diseases of the joints, are suffering from hysteria and from nothing else. The morbid sensibility is chiefly in the integuments, and if they are slightly pinched or drawn from the subjacent parts, the patient complains more than when the head of the femur is pressed against the acetabulum. There is likewise no wasting of the glutei muscles, nor flattening of the nates, nor painful starting of the limbs. In some instances the patient becomes paraplegic in the lower extremities, and is unable to walk, while others suffer temporarily from hemiplegia.

It is the extreme acuteness and exquisite sensibility of the senses in hysteria which has led those less skilled in female arts to believe in the many instances of animal magnetism which have formerly and lately attracted

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so much public attention. One of the most celebrated of them was enacted a few years ago by Miss M'Evoy, of Liverpool, who, being very hysterical, of exquisite nervous sensibility, and thus enabled to see at very low lights, professed to read with her fingers, a power which many ladies in France have recently claimed, as if the peculiar mechanism of the eye was unnecessary to the formation of the image of external things. The late attempts also to establish the existence of a new nervous principle, or of a mesmeric fluid, are probably entirely founded on that high state of hysteria into which some young women are so easily thrown, and which, in many instances, they can produce at will; and that this will is not wanting in all cases is manifest from the following experience of Dr. Prout:—"Innumerable instances" he says, "have occurred to me, for example, in which calculi have been said to have passed from the kidneys and bladder by hysteric females. Such calculi I have examined, and found to consist, perhaps, of a fragment of silex or of brick; in short, of anything but what is known to be of urinary origin; and the symptoms have been so acurately simulated and described, that those who witnessed them or heard them described have not appeared to doubt of the reality, till the pretended calculus has made its appearance, when its chemical properties have at once dispelled the illusion. Sometimes the properties of the urine have been changed, and it has been mixed with blood or mucus, or with quick-lime or chalk, or with ink."

In investigating, then, cases of hysteria, we should constantly remember that the utmost duplicity and cunning may be displayed, when from mere appearances we should expect nothing but the most rigid truth; in short, the whole energies of the patient's mind are bent on deception; as to the motives for such deception, that is another question. To become an object of attention, an interesting object, is an innate and characteristic feeling of the female mind.

*Diagnosis.*—The hysteric fit is distinguished from epilepsy by the countenance being much less convulsed, and by the shrieking, laughing, and crying by which hysteria is so constantly interspersed. The foaming of the mouth is also wanting, and the patient in general remembers what has passed during the paroxysm. It is often difficult to distinguish between the many painful affections of the joints which arise from hysteria and the formidable diseases they similate, and many mistakes have been made fatal to the health and even to life. The character, however, of the party, her time of life, her general good health, the intermitting nature of the pain, and its following the course of the nerve, enable us generally to determine with much accuracy between these different classes of disease. The most common mistake, however, is that of considering the pains under the mammæ as pleurisy, or disease of the liver, leading to a sad abuse of bleeding, blistering, and the exhibition of mercury. The state of the pulse, however, the general good health of the party, and most commonly the existence of some uterine irritation, is a sufficient diagnosis between these different diseases.

*Prognosis.*—The ultimate result of these cases, though often long and tedious, is always favourable. In some few instances insanity has been the result of this highly excited state of feeling, but the instances of this termination are rare.

*Treatment.*—The treatment may be divided into what should be done during the fit, and into what should be done afterwards.

When the patient falls into a fit the first thing is to loosen her stays and everything tight about her person. The window should be opened and the cold air allowed to blow over her. She should then be laid flat on the bed, or on the floor first, as a means of rendering the circulation through the brain more equal, and again to enable us the more readily to control the convulsive movements of her body. This being done, many modes of further proceeding may be followed. Some recommend, in plethoric cases, that the patient be bled; a remedy certainly in many instances manifestly improper, and in all of doubtful efficacy. When the jaw is locked, an enema, consisting of half a pint to a pint of assafœtida may be thrown up, or, what Dr. Elliotson thinks still better, two or three ounces of oil of turpentine, which in some instances, he adds, instantly removes the affection, but in other cases not for some hours. Another remedy is to fill the mouth with salt: "You generally see them come round if you fill the mouth with salt." The remedy, however, which supersedes all others, and is unquestionably the best, is a good drenching. If the patient be on the bed, the head should be drawn over its side, and a large quantity of water poured on it from a considerable height out of a pail, jug, or other large vessel, and directly over the mouth and nose of the patient, so as to stop her breathing and compel her to open her mouth. This practice is generally introduced into hospitals, and till it was adopted it was not unusual to see three or four patients in hysteria in the same ward, and at the same time. Under that practice, however, an hysterical case is rare, and the fit seldom occurs twice in the same person.

After the paroxysm is over, if the patient complains of continued headache, a few leeches to the temples may be necessary, especially if the urine be small in quantity and high coloured; but in all other cases leeches, blistering, or cupping should be avoided as much as possible, as tending rather to aggravate than control the disease. The next object is to regulate the bowels by such purgatives as may be necessary, and at the same time to support and tranquillize the patient by mild stimulants, as æther or assafœtida, combined with some mild opiate as the tinct. hyoscyami, the syrup of poppies, or small doses of morphia. The state of the uterine functions is next to be inquired into, and if they are defective, salicinæ gr. x. three times a-day, or gr. x. of the citrate of iron should be exhibited ter die. On the contrary, if leucorrhœa be present, or the menstruation be profuse, the mineral acids, or the potassii bitartratis will be found most efficacious by restoring a more healthy state of the deranged organs.

The urine is often suppressed for a time after an attack of hysteria; but unless the bladder be sensibly, and perhaps painfully distended, no attempt should be made to draw it off. Something more should be hazarded to avoid this necessity, for the catheter once passed, that operation will require to be performed morning and night, perhaps, for several months to come.

### Catalepsy

Is a rare form of disease, probably allied to hysteria, but whose laws and modes of treatment are not determined from the infrequency of its occurrence. It will only be necessary to give a few exemplifications of this singular affection.



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*Catalepsy* is a sudden suspension of all consciousness, and of all voluntary motion; but instead of falling down convulsed, as in hysteria, the patient, on the contrary, maintains the same position of the body, and the same expression of countenance he may chance to have at the moment of seizure; so that if sitting, he continues to sit; if standing, he continues to stand; and if occupied in any mechanical employment, he continues in that attitude; also, if the patient is under the influence of any passion of the mind, the countenance retains that expression—sic manus erecta non delabitur; faciei musculi ad risum aut fletum compositi risum vel fletum constanter exprimunt. This combination of fixed attitude and of unvarying expression gives to the patient the air of a statue rather than of a living being, and he appears as suddenly changed to stone as Niobe after exposure to the sight of Medusa's head. The most remarkable circumstance, however, in this disease is, that the attitude of the body and position of the limbs admit of being changed almost into as many new forms as a painter's lay figure, and the new position, however inconvenient, is preserved till again changed, or until the paroxysm has subsided.

Besides this singular state, all consciousness is suspended, and the patient neither receives any impression from external objects, nor retains any recollection of what has happened during the fit. The organic functions of life, however, continue to be performed, though feebly. The pulse and respiration are regular, only the former is smaller and the latter less frequent than in health. The colour of the countenance is either pale or undergoes no change. The fit may last a few minutes or a few hours, and is said to have lasted three or four days. The patient at length awakes as from sleep, and generally with a deep sigh, when all the functions of the body are suddenly restored. The attack is generally sudden and without any previous symptoms, but it is sometimes preceded by headache, stiffness of the neck, or some obvious torpor of the mind or body. The return of the paroxysm is very uncertain, but the disease seldom subsides with the first attack. The following case, given by Dr. Gooch, will best exemplify this affection.

A lady who laboured habitually under melancholy, a few days after lying-in was seized with catalepsy, and presented the following appearances. She was lying in bed motionless and apparently senseless. It was thought the pupils of her eyes were dilated, and some apprehensions were entertained of effusion on the brain, but on examining them closely it was found they readily contracted when the light fell upon them. Her eyes were open, but there was no rising of the chest, no movement of the nostril, no appearance of respiration. The only signs of life were warmth and a pulse, which was 120 and weak. Her fæces and urine had been voided in bed.

In attempting to rouse her from this senseless state, the trunk of the body was lifted up and placed so far back as to form an obtuse angle with the lower extremities, and in this posture, with nothing to support her, she continued sitting for many minutes. One arm was now raised and then the other, and in the posture they were placed they remained. It was a curious sight to see her sitting up staring lifelessly, her arms outstretched, yet without any visible signs of animation. She was very thin and pallid, and looked like a corpse that had been propped up and stiffened in that attitude. She was now taken out of bed and placed upright, and attempts were made to rouse her by calling loudly in her ears, but in vain; she stood up, indeed, but as inanimate as a statue. The slightest push put her off her balance, and she made no exertion to regain it, and would have fallen had she not been caught. She went into this state three times: the first lasted fourteen hours, the second twelve hours, and the third nine hours, with waking intervals of three days after the first fit, and of one day after the second; after this time the disease assumed the ordinary form of melancholy.

It might be supposed that something of this might be feigned; but in the following case any suspicion of this kind was impossible. The party seized was an insane male hospital patient. This man was suspected of imposture; when one day, being attacked, he was placed upright on the edge of the cold bath, and gently pushed till he fell to the bottom like a stone, and continued there without the slightest effort to save himself, till it seemed no longer safe to continue the experiment. After continuing in a cataleptic state for many months this man recovered. Some few instances are given in which the patient has retained a partial consciousness during the attack.

No treatment has yet been determined for this complaint.

### Chorea*

Is a singularly irregular convulsive action of the voluntary muscles, especially of the face and extremities, they being either entirely withdrawn from, or but little under the control of, volition. Fifty-four cases are reported to have died of this disease in England and Wales in 1839.

The history of this disease is a sad picture of superstition. As late as the close of the XVth Century, it does not appear to have been studied by physicians, but was supposed to depend on supernatural causes or diabolical possession. In Germany, it was said for two centuries to have been epidemic, and the patients, probably many of them maniacs, to have joined in frantic dances, and as late as 1673 they went in procession to the church of some favourite saint, of whom St. John, St. Guy, and St. Vitus were the most reputed. As physical remedies were supposed to be unavailing in such a disorder, the priests said masses, sung hymns, and sought to exorcise the foul fiend. Paracelsus is said to have recommended the afflicted to mould their own image in wax, to imprecate on it all their sins, and afterwards to burn it till every part was consumed. The moral effects of these methods must have been great, and no doubt many were cured in consequence.

*Remote cause.*—The disease frequently attacks children otherwise in good health, and without any obvious cause. When any cause is assigned, it is usually terror. Somebody has pretended to cut off the child's head, and perhaps has drawn the back of a knife across her throat; or a person dressed in a white sheet has enacted a spectre or ghost. The causes, therefore, producing this affection are chiefly mental. Mr. Mayo seems to think such a cause may produce the disease in a child yet in utero. A woman in the fourth month of her pregnancy had a frightfully disgusting object thrown at her bosom: she was for two months in a state of extreme nervous illness from this circumstance, but re-

* Χορεία (*Cœtus Saltantium*) St. Vitus', St. John's, or St. Guy's Dance.

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covered, and went her full time; remarking, however, that the child was extraordinarily lively in the womb, so that she was often overcome with the sensations she experienced. At its birth, the child, a girl, displayed the writhing motions of chorea, and continued up to the time Mr. Mayo saw her, when she was near thirty years of age, looking but an elderly child, with a head remarkably small, and a mind hardly removed from complete idiotcy.

*Predisposing Causes.*—Chorea is limited, or nearly so, to early life, and is rarely seen after twenty. Dr. Heberden states it to be most frequent between the ages of ten and fourteen, and also, that it is more common in the female than in the male, three-fourths of the patients under his care having been females. Dr. Elliotson says the ratio in his practice was eight males to twenty-two females; and these calculations are probably not far from the truth.

*Pathology.*—This disease is so constantly cured without leaving any trace behind, that it is unquestionably a disease merely of function. Rostan had once an opportunity of examining a woman upwards of fifty, and who, from her childhood, had laboured under chorea of all the left side of the body, and of which the limbs were atrophied. "I expected to find," he says, "atrophy of the right side of the brain, but there was nothing morbid; at least, after a most careful examination, I could see nothing." Dr. Bright has given one case, which he had an opportunity of examining, and which gives equally negative results. It was that of a young woman, aged seventeen, and who had formerly laboured under this disease. She had been free from it for four years, when she formed an attachment, was forsaken, attacked with chorea, and died. The attack was of great severity; she tossed herself about in all directions; bit her tongue, and was with difficulty in any degree controlled. On examination, there was a slight effusion into the arachnoid cavity, more puncta cruenta than usual, and five or six bony plates opposite the cauda equina; phenomena common to every disease of the brain or cord, and of course proving nothing.

*Symptoms.*—This whimsical disease principally consists in singular and involuntary movements of one or more limbs, which prevent the patient from being able to lay hold with certainty of any given thing, or to carry that thing, be it a spoon or a glass, with any certainty to his mouth, or to any other part. The lower limbs are generally as much affected as the upper, and he can with difficulty walk in a straight line, or if he does, it is always by a series of movements which tend towards the object, counteracted by another series which altogether diverge from it,—his feet turning in and out, upwards and downwards, or in every possible direction. The muscles of the face and neck are sometimes seized with this species of convulsion, when not only is the head tossed about, and the mouth contorted into the most singular grimaces, but it requires two or three persons to feed him, or one or more to hold him, and another to watch the proper moment to pop the food into his mouth. Sometimes the motor nerves of the fifth pair are affected, and then the jaw closes with a loud snap, or his articulation is affected, or the effort of swallowing difficult. Indeed, the patient is agitated by all sorts of odd motions, and has often a vacancy of countenance which gives him a fatuitous appearance. These convulsions are sometimes so violent as to render it necessary to tie him to his chair, or to strap him down when in bed. They are constant during the day, but when asleep, they generally cease altogether. In general, they affect both sides; but in a very few cases, one side only is affected, and the patient is then said to labour under a *hemichorea*. The child's health is generally good; his pulse natural, and his bowels, though occasionally constipated, are by no means uniformly so, but for the most part act regularly.

*Diagnosis.*—There is no disease which resembles chorea; but the variety hemichorea has been sometimes mistaken for hemiplegia.

*Prognosis.*—The recovery of the patient, with a very few exceptions, may be always prognosticated.

*Treatment.*—Sydenham prescribed three or four bleedings for the cure of this disorder, and after the last bleeding he directed the use of cathartics and alteratives until the patient was completely cured; a treatment which has probably been found altogether ineffective, as it has been entirely abandoned. The next heroic mode of treatment was suggested by Dr. Hamilton, of Edinburgh, or that by repeated purgatives; but this method in London, at least, has been also unsuccessful, for although purgatives are occasionally useful, yet, as the basis of the cure, they have been found to do mischief rather than good. The practice, therefore, of the modern school is, for the most part, limited to the exhibition of tonic and stimulant medicines, and to the cold bath. The particular tonic is not of much moment, but in general the mineral tonics are preferred. The sulphate of zinc will cure a large number, beginning with a grain, in the form of a pill, three times a-day, and increasing the dose till it reaches seven or eight grains. This quantity may seem large for a child, but Dr. Elliotson says he has given 20 to 25 grains, three or four times a-day to adults on an empty stomach, and without its causing even nausea. The gradually increasing the dose is essential, for we thus act on the mind, which is, perhaps, of more importance than the addition of power over the body. The influence of the mind in curing chorea was strongly instanced in the use of the nitrate of silver, a medicine which was once prescribed to a great extent at St. Bartholomew's Hospital, for as long as the pupils took a deep interest in the cases by watching the effects of this apparently powerful medicine all the most intractable forms of chorea recovered. No sooner, however, was it shown that the nitrate of silver was readily decomposed by the saliva, and consequently rendered nearly harmless, and the pupils less anxious about its results, than all its good effects suddenly vanished, so that it has ceased to be, or nearly so, employed for the cure of this disease.

The sub-carbonate of iron has an equal if not a greater effect over the disease with zinc, and Dr. Elliotson thinks he has cured 40 cases in succession with it. He recommends it to be given from six weeks to two months, in drachm doses, and mixed with double its weight of treacle; and children, he says, after a time like it.

Of other classes of stimuli, camphor in five-grain doses has acquired much reputation. Many young women, also, who attribute the attack to fright, get well under so simple a treatment as misturæ camphoræ, and spiritus ætheris nitrici, ʒ j. ter die; and when they labour under amenorrhœa, salicinæ gr. x. ter die is equally or more beneficial. A few cases have done well under nucis vomicæ, gr. ij. ter die, but the catalogue of possible remedies is endless. In many instances,



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however, the above medicines are continued for weeks without any manifest improvement, and in these cases the cold bath, or the cold shower bath is an excellent adjuvant, and, except the child is suffering from some structural disease, the case uniformly yields to this conjoined treatment.

*Dietetic Treatment.*—The diet should be light and nourishing.

TETANUS (*τεινω*) *extendo*—

Is a continued spasm of the muscles of the jaw, generally accompanied by intermitting spasm, either of all the voluntary muscles, or else of all the flexors, or of all the extensors of the body.

This disease was known to the ancients, and is described by Aretæus with all his usual terseness and precision. It is the frightful accompaniment of wars and battles, but occurs from accidents, or else spontaneously in a few instances in civil life, so that 122 cases are reported to have died from this disease in 1839 in England and Wales.

*Remote Cause.*—This disease is most frequently met with in armies on actual service, and is the result of wounds, especially of wounds made by large projectiles, as cannon-balls, bombs, &c., or of the amputations rendered necessary by those wounds. It follows also strains and contusions, and it is principally from these latter causes that it is met with in civil life.

Most authors consider it to be most common in hot variable climates, as that of Egypt. After the battle of the Pyramids, says Baron Larrey, upwards of 500 of the wounded were attacked with tetanus. The same authority also adds, that the tetanus of Egypt was much more intense than that he had observed in Germany. He states also, that this disease is much more common in all countries at those times of the year when the temperature passes rapidly from one extreme to the other, or in the spring, than in seasons when the temperature is more equal. Thus, after the battle of Eylau, fought during the depth of winter, not one of the guard, and very few of the line, were seized with this affection.

Besides wounds, strains, and contusions, some morbid poisons appear to produce this affection. Two men descended into a soap-boiler's vat to clean it out: on reaching the bottom, they both fell down in convulsions. They were quickly rescued, when it was discovered that a portion of sulphuretted hydrogen had been generated, and remained at the bottom of the vat. Both of these persons were seized with tetanus, of which they died. Strychnine is another poison also well known to produce this affection, and the poison of cholera, in severe cases, has also had the same result.

*Predisposing Causes.*—As the wound is the remote cause of tetanus, so its nature appears to predispose to the disease. Thus it is most common after injuries of the ginglymoid joints, as that of the elbow or knee, or when the bone is extensively fractured or comminuted. Its occurrence is also more probable if a foreign body remains in the wound, and especially if, after amputation, a nerve has been included in the ligature round the artery. In other respects, the state of the wound does not appear to influence the attack, for it appears to take place equally whether it be open or cicatrized, granulating or suppurating, incised or contused; but if there be any difference, Larrey thinks the detaching of the eschar, especially if the stump be exposed to cold, is the most critical period. It is singular, however, that time destroys the predisposition given by the wound; for Sir James Macgrigor gives as the result of his great experience, that no person is attacked with tetanus after the 22nd day from receiving the wound, a period which Sir Gilbert Blane extends to the fourth week.

All ages are liable to this disease, and even new-born children suffer from it, the "trismus nascentium" being ascribed to the tying of the navel-string. Tumbling boys are also frequently seized with this complaint. It is most common, however, in adult age; and if less frequent in old age, this circumstance is probably owing to persons in advanced life being little exposed to those accidents which usually produce it. Both sexes suffer from it; but men far more commonly than women. The ratio that died in 1839 was 102 men to 20 women.

*Pathology.*—The body has often been most minutely examined, after the patient has fallen from idiopathic tetanus, without any lesion being discovered; and when he has sunk from traumatic tetanus, nothing has been found in many instances, except, perhaps, the primary superficial wound. In a few cases the membranes of the brain have been found congested; but not in a greater degree than might have been predicated from the violent and long-continued muscular action incident to the disease. In a smaller number of instances small patches of cartilages or of bony matter have been found on the spinal arachnoid membrane; but as these are often absent, they are not essential conditions of the disease. It seems proved, therefore, that tetanus is a disease of function; and, as Majendie has shown, if the spinal cord of a living animal be divided into as many segments as there are vertebræ, that the animal, if poisoned with strychnine, still becomes tetanic, although all direct connexion of the muscles with the brain is destroyed; it seems probable that the cord, as high as the fifth pair, and not the brain, must be the great seat of this affection.

*Symptoms.*—There are five varieties of tetanus—or trismus, tetanos, emprosthotonos, opisthotonos, and pleurosthotonos; and when either of these diseases terminates within eight days, it is said to be acute; but if prolonged beyond that time it is termed chronic.

Trismus is that state in which the disease is limited to the muscles of the lower jaw and throat. Tetanos is marked by the flexor and extensor muscles of the body generally being equally and strongly contracted, keeping the whole frame in such a state of tension that if you attempt to raise the leg, you, according to Baron Larrey, raise the whole body, it being as inflexible as in death. Emprosthotonos is when the flexor muscles bend the body forwards. Opisthotonos when they bend the body backwards; and pleorosthotonos is when they bend it laterally, or on one side only.

The frequency of occurrence of these different forms of tetanus is not accurately determined; but trismus is the most common: and though it may exist *per se*, it is generally the first and concomitant symptoms of all the other forms. After trismus, opisthotonos is far the most common, both in this country and throughout Europe; but Baron Larrey says that emprosthotonos was most common in Egypt. Of pleurosthotonos only a very small number of cases are to be found recorded in the whole annals of medicine.

The attack of either form of tetanus may be sudden; but more frequently it is preceded by an uneasy sensation and tension of the præcordia, followed by stiffness

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of the neck, shoulders, and lower jaw. At length the patient feels a sudden and painful traction of the ensiform cartilage; and this latter symptom is considered the pathognomic sign of the disease. Shortly after this the jaw becomes locked, and cannot be opened even to admit the little finger. At this point the disease may stop, and the phenomena be limited to trismus; but more commonly the patient takes to his bed, and the disease assumes one of its severe forms, as of opisthotonos, emprosthotonos, pleurosthotonos, or of tetanus.

In opisthotonos, in addition to the trismus, the muscles of the face are generally spasmodically affected, for the brow is knit, the corners of the mouth are drawn, giving to the patient a most wretched grin, or the risus sardonicus. The eyes also are almost motionless and sunk in the socket; and, during the attack, the tongue is projected against the teeth, so, except for the trismus, it might be caught by a convulsive snapping of the jaws, and severely injured. The characteristic of this form of the disease, however, is, that the flexors of the back are thrown into such powerful action that the spine becomes arched, and sometimes to such a degree that the body rests on the occiput and heels, as on the extreme points of the segment of a circle. The flexors of the back, however, are not the only muscles affected, for the shoulders are thrust forward by a strong action of the pectoral muscles, while the extremities are elongated and tightly braced by strong contractions both of their flexors and extensors. Indeed, the whole of these different sets of muscles are thrown into action at the same moment, as if by the discharge of a powerful galvanic battery. The shock is transitory; and, having passed off, an interval succeeds which varies from a few minutes to half an hour, an hour, two hours, or longer, according to the severity of the disease. But during this interval the patient lies as in his coffin, with his arms close to his sides, and his legs stretched out and touching each other, fearing lest the slightest motion should produce a recurrence of the attack. His nights, or such few as he lives through, are sleepless, or only marked by a few minutes broken slumber. Such is an attack of opisthotonos. The other forms of the disease differ only by the different sets of muscles affected.

It is difficult to give an idea of the distressing violence of the spasms; but they may be imagined when it is stated that Desportes gives a case in which both thighs were broken. But notwithstanding this strongly powerful action of the muscles, the patient's mind is seldom affected, and his pulse presents its healthy beat, only a little accelerated. The intercostal muscles partaking in the general spasm, the respiration is carried on principally by the diaphragm; and, when the attacks are frequent, the breathing is short and laborious. The skin is, after a short time, covered with a profuse sweat, as during great exertion. The tongue is clean and moist; but the bowels are generally constipated, and the sphincter ani so contracted, that it is difficult to introduce a glyster-pipe. In cases in which tetanus supervenes on a suppurating wound, the sore dries up and is painful, while the muscles of the part are highly irritable.

In mild cases the paroxysm returns only three or four times in the twenty-four hours; while in severe cases it returns not only every hour or every quarter of an hour, but every motion of the body or attempt to open the mouth is followed by an attack. In the last stage the situation of the patient is most pitiable, the spasm returning every few minutes, till he is at last cut off by one of unusual violence.

The duration of this disease is very various; in some instances death occurs in twenty-four hours; more commonly on the second, third, and fourth day, and, when fatal, is seldom protracted beyond the eighth. Some few persons survive till the seventeenth or twentieth day; and in this case the disease generally terminates in recovery.

*Diagnosis.*—The jaw is sometimes locked by enlargement of the cervical glands, and also in some forms of hysteria. The tumor, however, in the one case, and the hysteric passion in the other, are circumstances which readily enable us to distinguish them from trismus. The formidable phenomena of tetanos is seen in no other disorder except cholera; but the other differences between the two diseases are so extremely marked, that it is impossible not to distinguish them.

*Prognosis.*—The prognosis in this disease is always most grave. In the Peninsular war, although hundreds of cases were treated in every different manner, yet few, very few survived. In civil life the chances are something more favourable; and if the accident be of little moment, and the patient very young, he sometimes recovers. Dr. Parry thinks, if the pulse be not more than 100 or 110 up to the fourth or fifth day, the patient almost always recovers. The danger decreases in general also in proportion to the duration of the disease, for few patients die after the fourteenth day. The danger in the early stages is to be estimated by the frequency and violence of the paroxysm.

*Treatment.*—Baron Larrey affirms that this disease, if left to nature, is quickly fatal.

One of the most remarkable features of this complaint is the insensibility of the brain and nervous system generally to the action of our most powerful remedies; so that they are not merely inefficacious, but almost inert. Sir James Macgrigor says that all the most powerful remedies were fully tried in the Peninsular war; and that little or no dependence could be placed on any of them. Opium was largely tried after the battle of Albuera, and given in the enormous dose of twenty grains every three hours; and yet it not only failed in curing the disease, but did not even produce sleep. Mercury was tried after the battle of Salamanca, and to such a degree, that strong mercurial ointment was rubbed in three times a-day in unlimited quantity, yet it entirely failed. One man, strongly under the influence of mercury, was seized with tetanus and died. While Baron Larrey's experience in Egypt led him to believe that mercurial frictions only aggravated the disease. Opium and mercury were then combined; but, according to Sir James Macgrigor, the combination was as inefficacious as their separate exhibition. Wine and brandy were used in unlimited quantity; but without producing intoxication, or mitigating the symptoms. Many other stimulants, as musk, æther, camphor, were afterwards employed, but equally without success. Venæsection had also a fair trial in several quarters, and in a great number of cases; but only one man recovered. Tobacco glysters are not only not serviceable, but have been sometimes followed by the instant death of the patient. Digitalis has equally disappointed the hope which had been entertained of it; and one man is said to have died under its depressing influence. Prussic acid has also been tried and failed. Dr. Elliotson speaks in high terms of the carbonate of iron; and he

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has given it to the extent of 2 lbs. in the twenty-four hours; and under this treatment two out of three cases recovered. The instances, however, are far too few to enable us to decide on the value of this medicine, especially as a very long period has elapsed without any confirmatory evidence. The warm bath has been thought serviceable in some cases; but patients have died while immersed in it. The cold bath is worse than useless; it is dangerous. Baron Larrey speaks of a patient who had twice gone into the cold bath, but with so little benefit that he absolutely refused to encounter a third. A blanket, however, was thrown over his head, and he was then plunged into the water. He died a few hours after, when it was discovered he had ruptured the sterno-pubian muscle in all its thickness. Dr. Elliotson speaks of a case in which the patient was taken out of bed and placed in a tub in the middle of the ward, when a pail or two of water was dashed over him. The man fell down dead as if he were shot.

It appears, then, that all the heroic modes of treatment medicine offers have been tried and failed. Much good, however, is gained by attempting to restore, especially in idiopathic tetanus, the secretions to a healthy state; also by supporting the patient, and by endeavouring to tranquillize the high irritation under which he is labouring. In St. Thomas's and in St. Bartholomew's Hospitals several cases have been restored by this means. The medicines employed were moderate doses of purgative medicines, with tinct. opii ♏ v., or its equivalent, 10 grains of Dover's powder, given every three or four hours; and these were conjoined with moderate quantities of wine, sago, or other nutritious diet. Musk also, in ten-grain doses, has been given with some advantage.

Some authors lay much stress on a local treatment in traumatic tetanus. Baron Larrey, as the result of his great experience, says, "When it is caused by the wound, we should not hesitate to operate on the first symptom of tetanus, and thus, as far as possible, remove the causes of irritation. If tetanus follows amputation, &c., he recommends the stump to be sprinkled with powdered cantharides; and in cases where a nerve has been included in the ligature, that the ligature be removed either by section, or by actual cautery. In the British army, however, all these proceedings have been adopted, and with very little success, for amputation has been frequently performed without any mitigation of the symptoms. The wound has also been excised, submitted to actual cautery, been blistered, and dressed with every ointment; but in general the disease has run its course, either uninfluenced, or else its fatal termination has been accelerated. Hennen has even seen the wound heal and the patient die on the same day. Nothing, in fact, is so unsatisfactory as the results yet obtained from either the general or local treatment of this fatal affection. Larrey has often attempted, from the difficulty of swallowing fluids that sometimes attends this complaint, to pass an elastic tube; but in all cases he says he met with a contracted state of the œsophagus impossible to overcome; while the attempt was constantly followed by the immediate occurrence of the severest spasmodic attacks.

### Neuralgia.

Besides the functional diseases that have been mentioned of the brain and cord, the nerves they give origin to are likewise often the seat of functional disease. Thus the nerves of sensation are frequently the seat of excruciating pain, ever returning, and this affection is termed Neuralgia. If from any cause the sensation of a part is dull, benumbed, or entirely lost, the disease is termed Anæsthesia. On the contrary, if there be an entire loss of motion in a part, the disease is termed Paralysis; or, if the action of the part be irregular and violent, it is termed Spasm or Cramp.

### Of Neuralgia or Tic Douloureux.

This disease of the nerves was known to Galen; but the more complete development of this branch of medicine is of modern date, and is owing very principally to the labours of Parry and Jenner, of Chaussière, of Sir Charles Bell and Mr. Mayo. No death is reported of this disease in England and Wales in 1839.

*Remote Cause.*—The remote causes of this class of affections are extremely undetermined, but they are supposed to be extremes of heat or cold—or sudden changes from the one to the other. It is also often a result of impaired general health. Thus women after profuse menorrhagia, or after child-birth, or persons recovering from fever or other severe disease, often suffer from neuralgic affections. Arsenic also appears to be a cause; at least persons who have attempted to poison themselves with that mineral often suffer agonizing pains in the limbs. Blows or wounds, or the pressure of an aneurismal or other tumor, sometimes seated in the nerve itself, are also causes of neuralgia.

*Predisposing Causes.*—Of 123 cases observed or collected by M. Chaponière, only two cases occurred in children under ten years of age. Tic douloureux seldom therefore occurs before puberty. An equal number is supposed to occur in each ten years of the period between twenty and sixty, showing the great tendency to increase with age. As to sex, this disease is more common in men than in women; and in women it occurs rather more frequently before thirty than afterwards, especially in those whose menstruation is irregular either as to time or quantity. The place of abode, manner of living, trade or profession, and as far as has been traced, hereditary predisposition, have little influence on the production of the disease.

*Pathology.*—Sir Charles Bell and Majendie have carefully examined the affected nerves after death in neuralgia and found them healthy. In some few instances, some morbid appearances have been observed, but only such as are probably accidental, or the consequences of the disease itself, as redness or atrophy of the nerve. On examining the head of the late Dr. Pemberton, for example, there was found an unusual thickness of the os frontis, and also a little ossific deposition in the falciform process. In another case, also, Sir Henry Halford has observed a similar thickening of the frontal, ethmoidal, and sphenoidal bones. But osseous formations in the dura mater, and also thickening of the bones of the cranium, are often met with without any symptoms of tic douloureux. Painful affections of the nerves have also occasionally occurred in consequence of cancer or other diseased structure of the brain, but not necessarily so. The labours of the anatomist have therefore thrown little light on this affection, and consequently the essential nature of neuralgia is merely a disordered function of the nerve.

*Symptoms.*—All authors have observed that the most superficial nerves are those which are principally if not solely affected with this disease; and of those nerves the following are the most frequently so:—

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| Numbers attacked. Men. | Numbers attacked. Women. | Systems of Nerves. | Particular Seat. |
|---|---|---|---|
| 124 | 142 | Trifacial nerve. | Supra-orbitary nerve.<br>Infra-orbitary.<br>Inferior maxillary.<br>Nasal, Temporal } rare. |
| 9 | 9 | Cervico-occipital. | Occipital.<br>Mastoidean. |
| | | Brachial. | Cubital.<br>Musculo-cutanei.<br>Radial.<br>Median: very rare. |
| | Women in large numbers. | Dorso-intercostales. | Dorsal.<br>Intercostal. |
| | | Lumbo-abdominalis. | Lumbar.<br>Ilio-scrotal. |
| | | Crural. | Tibial. |
| 75 | 52 | Femoro-popliteal | Femoro-popliteal.<br>Peroneal nerve.<br>External plantar nerve.<br>Internal plantar nerve. |

The symptoms of tic douloureux are similar, whatever be the nerve affected; it is therefore proposed only to treat of those of the trifacial, as being the more usual seat of this trying complaint.

The most common seat of tic douloureux is the fifth pair of nerves, or the nerves which give sensation to the face; and the frequency with which its different branches are attacked is in the following order. The infra-orbital or pes anserinus, the supra-orbital, and lastly, the inferior maxillary nerve. These branches may be attacked separately or conjointly; most commonly, however, only one branch is affected, less frequently two, and the case must be severe in which the three branches or the whole side of the face is affected.

The attack of this disease is sometimes sudden, but more generally it is preceded by a dull aching pain at the points where the nerve issues from the cranium or becomes superficial. After this threatening symptom has lasted a few hours or a few days, the patient is seized with a violent darting or shooting pain in the course of the nerve, returning at intervals, and which is the characteristic of the disease. The paroxysm is short, lasting only a few seconds or a few minutes, but the pain is perhaps the most severe that the human frame is capable of suffering. Some patients have compared it to an electric shock of great intensity, others to the conflagration of gunpowder, and others to the intensity and violence of a fulminating powder. The late Dr. Pemberton was known to have stamped the bottom of his carriage out during the paroxysm; and Valleix mentions a physician who, suffering from this disease, was induced, by excessive agony, to make deep incisions into his face, and then to apply actual cautery to the wound; but his pain not being mitigated by these methods, he several times attempted suicide. Even in mild cases, the patient often on the instant of attack becomes fixed like a statue, fearing to move a muscle or a limb lest he should aggravate the pain or reproduce the seizure.

In cases of ordinary intensity the effect is so completely limited to the nerve that even the skin is not discoloured, while the organs immediately in connexion with it are little affected, the eye perhaps being only watery, the nose hot, and the teeth aching. In severer cases, however, and where the disease affects the nerve generally, the condition of the patient is most lamentable. The mouth is spasmodically drawn as in palsy, so that the saliva flows over the chin and neck. That fluid also is increased in quantity and altered in quality; for in cases in which the patient is afraid to clean his teeth lest the paroxysm should return, the whole of the teeth of the lower jaw have become so incrusted with tartar as to form one solid mass. The eye and eyelid are likewise frequently convulsed, the conjunctiva injected, the nose discharges a muciform matter, the very hair of the head is painful, and the affected nerve may be traced by a red line marking its course.

The recurrence of the paroxysm is very various: in slight cases it may return only once in a few weeks, or in a few days; but in severe cases it will return every quarter of an hour, every five minutes, or every minute, and even every few seconds. In a few cases (ten out of forty-six) the paroxysms occurred periodically and at stated intervals. Yet in general the times of recurrence are very uncertain, sometimes the patient being attacked with great violence many times a day for many days or weeks together, so that the disease is almost continued; and then it intermits for a week, a month, six months, or a year.

It has been imagined by Bellingeri that the attack usually takes place before the middle of the day, but this rule is liable to many exceptions, for it often occurs in the night as well as at all times of the day. The disease is situated nearly as often on the right as on the left side of the face, or, according to Valleix, twenty-three times on the right and twenty-one times on the left, and only twice on both sides of the face. Pressure over the diseased nerve rarely increased the pain, or only in three cases out of twenty-one.

The total duration of the disease is very various. In some cases it terminates after a few paroxysms, in others it lasts from one to six months, and in some cases it becomes chronic and lasts the whole period of a long life. It seldom disappears suddenly, but oscillates with a decreasing intensity; the intervals gradually becoming lengthened till at last the disease subsides.

*Diagnosis.*—The disease to which neuralgia bears most resemblance is rheumatism, but it is distinguished from it by the transitory nature of the attack and by the absence of all swelling. Valleix gives also as a diagnostic symptom, that there are certain points which, being pressed in the interval of the paroxysm, give pain. These points are four-fold, or 1st, Where the nerve emerges from the bone, as at the supra-infra-orbitary, and mental foramina, in trifacial neuralgia. 2ndly. Where the nerve, passing through muscles, reaches the skin. 3rdly. Where the nerve terminates in the skin; and lastly, where the nerve becomes very superficial, as the cubital and peroneal nerves.

*Prognosis.*—This disease has very rarely terminated in death, and in general the patient's health is good throughout its whole course.

*Treatment.* — Almost every practitioner has some specific mode of treatment for this disease. The late Dr. Baillie recommended sarsaparilla,—Mr. Hutchinson the sulphate of iron, — Dr. Elliotson the carbonate of iron, — others have greatly praised arsenic, — others mercury, or the disulphate of quina. Bleeding, either local or general, has had its advocates, while its opponents affirm this operation to be always useless and sometimes injurious. There can be no question that

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the disease has often subsided under the use of all these various remedies; but the tendency in neuralgia to a spontaneous intermission is so great, it is doubtful whether in any case they can be said to have cured it. Opiates are unquestionably serviceable in mitigating the sufferings of the patient, and perhaps in influencing the disease, but not to the extent generally supposed. "Belladonna, both internally and as a plaster, will relieve the pain; and some persons," says Dr. Elliotson (note, p. 507), "have *said* they have seen it cured by it. Stramonium and opium have a similar effect; but in general you may give these things till you induce vertigo and apoplexy, and yet the pain will get no better. Belladonna and perhaps stramonium are better than opium, and they appear to have done occasionally good."

When these or other general remedies have proved insufficient, recourse has been had to local remedies. The most efficient of these applications is supposed to be the ungentum aconitinæ, or else an ointment of morphia, and likewise blisters, and the disease has often subsided under their use. Steaming the head, and the warm bath, are equally or even more beneficial. The belladonna plaster is a most favourite application.

When general and local applications are unsuccessful, the cause is often sought in a diseased tooth or stump, and in a *very few* instances an exostosis of the stump has been discovered and the disease cured. More commonly, however, even when the patient submits to have every tooth in his head drawn, no relief or benefit has resulted.

Besides extracting the teeth, a last resource is, dividing the nerve; but even this operation is very uncertain. Complete division of the nerve, with excision of a portion of it, so as to prevent union by the first intention, has been practised over and over again, but with only temporary benefit. The division of the nerve also has this disadvantage, that when most successful it is often followed by numbness and loss of power of the part affected, but the more distressing circumstance is, that the neuralgia has so frequently returned that few surgeons are now inclined to operate for the disease. In some few instances, when the neuralgia has been the result of a puncture, the removal of the cicatrix has cured the patient; but there are many exceptions to the success even of this operation.

### Anæsthesia, or Palsy of the Nerves of Sensation.

An excess of sensibility of the nerves is the characteristic of neuralgia, but the nerves of sensation may suffer from a directly opposite state, or from a defect of sensibility—a numbness or a complete loss of sensation. The cutaneous nerves are those most usually affected, and from this cause the disease most usually attacks the integuments of a portion of the trunk, or of an arm, or a leg, or some given portion of the extremities, and also the whole face or parts of the face, indicating an affection of the fifth pair.

As the remote and predisposing causes of this disease, as also its seat, are similar to those of neuralgia, so its pathology, likewise, is equally negative, or with no other peculiarity than being more frequently connected with disease of the brain. As the symptoms, moreover, are so marked that it is impossible to mistake them, it seems unnecessary to do more than to point out two remarkable laws incident to this form of the disease. The first is, that parts do not waste in anæsthesia as in muscular palsy, which is singular, for the nerves of sensation and of motion, with the exception of the fifth pair, appear throughout the body to be inseparably connected and contained in the same sheath. The second law is, that in anæsthesia, the nerve affected, though insensible as to touch, still remains sensible to changes of temperature. The treatment of anæsthesia, unless the disease be connected with the brain or spinal cord, principally resolves itself into attention to the general health.

The diseases of the nerves of motion are—*Paralysis, Paralysis Agitans, and Spasm.*

### Of Paralysis of the Nerves of Motion.

Palsy of a part is a very constant symptom of structural disease of the brain or of the spinal cord, but it occasionally happens from mere diseased function of the nerve itself. Palsy, from this cause, may affect a finger, a hand, an arm, or a leg; but its most frequent seat is the seventh pair or facial nerve. Two cases of this kind were recently admitted into St. Thomas's Hospital, in which the brow was motionless, the mouth drawn, and with the eye red from inability to close the lid. In severer cases, the lower eyelid is everted and the tears flow over the cheek. The eye, if the disease be prolonged, inflames either from its constant exposure to light, or from the presence of other irritating causes removed in health by the action of the eyelids. The eye, also, is sometimes turned outwards from palsy of the third pair, and sometimes inwards from a similar affection of the external motor of the eye. When the third pair is palsied, the upper eyelid, to which it sends branches, often falls down, covering the eye entirely, and is so completely powerless that it cannot be raised except by the hand; and this state is termed *ptosis.* Sometimes the nostril, also, is motionless and flattened. This disease arises from cold damp weather, mechanical violence, or other general cause. It seldom occurs till adult age. No further pathological phenomena or symptoms attend it. The treatment is by blisters behind the ear, and by attention to the general health.

*Paralysis Agitans* is a minor affection of this class, and consists of a feeble trembling action of the muscles, not amounting to palsy. The nervous fluid is consequently not altogether wanting, but is deficient in quantity, and exhausted by the slightest action of the muscles, as in old persons. This disease is met with most commonly among gilders and silverers of looking-glasses, and the class of persons who work with mercury. It is also frequent in the drunkard, in the aged, and in persons who have suffered from cerebral or spinal structural affections; it consequently seldom attacks young persons, but is most usual between the ages of 40 and 60. The bodies of those who have fallen from this disease have been examined; but, except in those cases in which it has depended on cerebral or spinal lesions, no pathological phenomena have been found. This muscular weakness may be general or partial. When general, almost every fibre quivers, so that to raise any liquid to the mouth without spilling it is impossible; and if the patient attempts to walk, he steps short and quick, treads on his own toes, and is almost obliged to run to keep himself from falling. When the disease is partial, the head often shakes like that of a Chinese mandarin, or one hand or arm may be in incessant motion. In one case lately, in St. Thomas's Hospital, the patient, a man about 30,

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beat the devil's tatoo with his left leg, whether sleeping or awake, for many weeks, to the great annoyance of the whole ward.

Paralysis agitans is a very obstinate disease; and Dr. Elliotson does but speak the sense of the profession when he says, "I have not been by any means successful in the treatment of this disease. I believe, when it occurs in old people (when the hand shakes, or the head), you can do no good; at least, I have never known good done. Where it has occurred pretty universally, I have never been able to cure but one case, and in that instance the patient was not old; he was not above 35 years of age. After using other remedies unsuccessfully, I then exhibited sub-carbonate of iron, under the employment of which he became pretty well, and remained so for some time afterwards. I have since had four or five other cases under my care, and have exhibited the same medicine, but it has not produced the least benefit."

### Spasm—Cramp.

Many persons are habitually subject to a spasmodic action, or tic, of some one muscle of the face. When the contraction, however, of the affected muscle is attended with pain, it is termed *cramp*. Many persons, and of all ages and of both sexes, are greatly subject to cramp; and the parts it most commonly affects are the arms or legs, or the abdominal muscles, and especially the rectus. It is most commonly excited by cold; and, from this circumstance, so many young persons are drowned, seized with cramp while swimming. It also often occurs during sleep, and while the patient is warm in bed. It is produced, also, by causes which greatly exhaust the nervous power. Thus, women are often seized, either immediately after or during parturition; it also often occurs in the course of a severe diarrhœa. No pathological lesion attends this affection. The symptoms are manifest. The return of the attack, in ordinary cases, is extremely uncertain, and so is its duration when present. It seldom, however, lasts more than a few minutes, though occasionally its duration is much longer. The treatment of this affection appears to be, first to rub the part, and then to apply warmth when it is caused by cold, and cold when it is caused by warmth, and to throw the whole weight of the body on the leg or other affected part, so as to overcome the spasmodic action of the muscles. If the disease be distressingly frequent, the treatment consists of baths, friction either with the flesh-brush or else some stimulating liniment containing an opiate, and also by attention to the general health.

### Of the Neuroses of the Alimentary Canal.

The importance of healthy digestion, and consequently of a healthy state of the digestive organs, for the preparation of our food, has been acknowledged by all writers; and, indeed, Mr. Hunter, on this account, appears to have considered the stomach as the great centre of animal life. The diseases, however, of this system are numerous, and have employed the pens of an endless number of writers; and by none have they been better treated than by those of our own times, as Philip, Prout, Abercrombie, Mayo, and Johnson.

*Remote Causes.*—The remote causes of these affections are very multifarious, and may be divided into *general* and *specific*. The general causes are errors in the quantity, quality, or temperature of our diet. Atmospheric vicissitudes, the play of the passions, and chemical or mechanical injuries. The specific causes are perhaps endless; but there are four of more importance than the rest,—alcohol (however combined, whether with beer, wine, or drank as spirits), lead, salted provisions, and some fish poisons; and of these it is proposed to treat at some length. In addition to these general and specific causes, we may perhaps, without impropriety, add intestinal worms, calcareous, biliary, as well as certain organic intestinal concretions.

*Predisposing Causes.*—The present state of the constitution greatly influences the functions of the alimentary canal, for there exists that sympathy between it and every other part of the body that the one is seldom disordered but the other immediately suffers. Almost every disease, therefore, whether an ulcer of the leg, an eruption of the skin, an abscess of the liver, or a headache very constantly, deranges or destroys the healthy functions of digestion.

*Age* has also much influence, as a predisposing cause, over this class of disease. The infant cannot live on the food which nourishes the child, the child on the diet of the adult; and again, in old age, we can hardly masticate or digest with facility the diet of our early years. Each age has therefore its appropriate nourishment; but slight errors are felt much more seriously in the extremes of life than at its adult and middle portion. The *habits* of life affect the powers of digestion almost as much as age, for the hardy countryman often lives on food which would destroy the effeminate townsman. *Sex* has also much influence in producing disordered states of the digestive organs. The female eats, perhaps, oftener than the male, but her appetite is more delicate, and her sedentary habits are unfavourable to digestion. Having thus briefly mentioned the *causes*, generally, of the neuroses of the alimentary canal, it will now be necessary to speak of its particular disorders, and of their particular causes; and first, of Dysphagia.

*Dysphagia.*—The œsophagus is a fibrous canal by which the food descends from the mouth into the stomach, and is sometimes so irritable and sometimes so completely void of power, so palsied, that it opposes an obstacle to the introduction of either solid or liquid food into the stomach; and this difficulty of swallowing is termed dysphagia.

The causes producing difficult deglutition are in general connected with some previous state of ill health, as phthisis. It is not uncommonly a consequence of mental affections, as of hysteria or insanity, the latter class of persons often falling from a sudden palsy of the œsophagus, so that the food being retarded in its passage at the root of the tongue, makes its way into the larynx. A case of dysphagia is now in St. Thomas's, caused by a bony enlargement of the thyroid gland; and any other tumor, external or internal, pressing on the œsophagus, will equally produce a similar result. It will only be in our power to give an example or two of this affection.

A woman was admitted into one of the large hospitals in London, complaining of an entire impossibility of passing anything into her stomach, and that whatever she attempted to swallow was immediately returned. A probang was passed, and as it was stopped before it reached the stomach it was supposed she was labouring under cancer of the œsophagus; an opinion which was the more strongly confirmed, as she became daily more



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and more emaciated. At length, however, at the end of many days, she made an effort to vomit, and threw up a piece of beef of considerable size, and which she now remembered she was eating when first seized. She entirely recovered; and consequently a permanent spasm of the œsophagus must have existed in this person for a great many days.

Mr. Hunter gives a case of palsy of the muscles of deglutition so complete that the patient was obliged to be supported by nourishment injected into the stomach by means of an elastic tube. She, however, recovered, and, as Mr. Hunter imagined, by taking a drachm of valerian and two scruples of flour of mustard daily. Pinel gives a case of one of the nurses of Salpêtrière, aged sixty, who laboured for six months under a violent dysphagia; and Hoffman describes also a similar case. It is remarkable that both these cases were cured by accident; for Pinel had ordered a drachm of camphor to be rubbed up with olive oil and used as a liniment, when by mistake the woman took the entire quantity in the course of the night; while Hoffman had ordered for his case half a drachm of camphor to be rubbed up in the same manner, and to be taken in divided doses; but the woman took the whole quantity at one draught.

The *Neuroses* of the stomach, from general causes, may be divided into those which, as far as we know, are unaccompanied by any morbid secretion, and into those in which the secretions are vitiated; although it must be admitted the two forms of disease often co-exist. The former, however, embraces gastralgia, emesis, ruminatio, pica, bulimia, abstinentia, and polydipsia. The latter includes cardialgia, pyrosis, cholera vulgaris, and pneumatosis.

*Gastralgia*, or stomach *Colic*, is a severe pain in the stomach, often so completely idiopathic that the slightest cause produces it. One person cannot eat a strawberry, another a gooseberry, another an egg, without being seized with it. In other cases, every sort of diet produces it, so that the patient is racked with pain after every meal. The parties affected are usually adults; and women are more frequently the subject of it than men.

The attack of *colic* is generally sudden, and the patient unexpectedly seized with a pain in the stomach, which attains its greatest height on the instant. This pain is so violent that it either bends him double, causes him to roll on the floor, or else to lie flat on his belly, making strong pressure on the abdomen, and which pressure he fortunately finds gives him relief. This attack is generally accompanied by sickness or vomiting, by great flatulence, and by a confined or purged state of the bowels. It may last from a few minutes to a few hours, and often ceases as soon as the stomach is emptied or the bowels have acted; but when the patient is costive, it very constantly continues till he is relieved by medicine, when it subsides almost as rapidly as it commenced, leaving however a soreness behind it. The pulse, in this affection, is natural; there is no fever, and the pain is relieved on pressure; circumstances which readily distinguish it from inflammation. The disease may subside after one attack; but genuine gastralgia sometimes lasts for many months, as in the following case:—

Barras, author of the "Traité sur les Gastralgies," was subject to neuralgia of the face and spermatic cord, when he was one day seized, two or three hours after eating, with a pain in the stomach, as if that viscus was compressed in a vice; he also felt much nausea. These symptoms having lasted for some time, ceased with the eructation of a great quantity of wind. Similar attacks recurred at short intervals, during some months, and were so intolerable that he became emaciated, hypochondriacal, and disgusted with life. He applied a great number of leeches to the epigastrium, and took a great variety of medicines without relief, but was at last cured by the shock caused by the death of his daughter. The treatment of this disease is by mild opiates and gentle cathartics.

Besides being the seat of most severe pain, the nerves of the stomach may be morbidly sensible as to the quality of things eaten, as in pica; or as to the quantity of food, as in bulimia, polydipsia, and in anorexia.

*Pica** is a depravation of appetite, so that the patient desires to eat substances more or less unnatural; or, as it is usually termed, has "a longing." The causes of this affection are not determined; but the parties usually affected are pregnant women, the insane, and chlorotic persons of both sexes. The appetite, in these cases, is extremely capricious, being sometimes entirely wanting, and then voracious, but only for particular substances. The objects of desire, in this disease, are very various, as cinders, spiders, lice, flies, insects, toads, wood, hair, paper, earth, clay, chalk, vinegar, and even fæcal matters. Our medical records abound with cases of the following kind:—Dr. Elliotson met with a lady who fancied brown paper; "not paper hot-pressed and gilt-edged, but brown paper." Dr. Copland gives the case of a man who occasionally delighted to indulge himself in devouring a whole wine or ale glass, crumbling it between his teeth. A child, affected with epileptic fits, eagerly swallowed skeins of silk, reels of thread or cotton, needle-cases, buttons, or whatever came in his way that he could force down his throat; at length, nothing else being to be found, he ate the outer shell of the walnut, till his mouth and throat became painfully sore, swollen, and excoriated. In every mad-house there are young women fond of fæcal matter, who require to be watched every time they go to the water-closet. The longings of pregnant women are notorious. One longed for red-herrings, and actually ate 1400 of them between conception and parturition; another longed for a bite of a butcher's shoulder, and another for a bit of a priest's sleeve; but there is no end of these caprices.

Perhaps the most remarkable instance of pica is the irresistible propensity which the inhabitants of some countries of the torrid zone have to earth-eating. In Guinea the negroes eat a yellowish earth, called cavuac. Humboldt, on his return from the Rio Negro, fell in with a tribe of Ottomacs, who lived, during the rainy season, principally on a fat unctuous clay, each individual consuming from three-fourths to four-fifths of a pound daily; and in the dry season they usually ate a small portion as a relish. In Japan, cakes of reddish earth, called tanaampoo, are exposed for sale, and bought by the women to improve their beauty, slenderness of form being esteemed among the Japanese. In the West Indies, dirt-eaters, as they are termed, acquire a stronger attachment for a white clay, like tobacco-pipe clay, than either for spirits or tobacco. Their delight is to fill their mouths with it and allow it to dissolve; a practice which extends to negroes of all

* From pica, a pie; a bird said to be liable to this complaint.

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Elementary Principles of Medicine.

ages, for even children acquire it almost as soon as they leave the breast. Dr. Hunter states that a negro labouring under this malady is considered as irrecoverably lost for any very useful purpose, and that he seldom lives long. The treatment of this affection is attention to the general health, and the exercise of moral influence.

*Bulimia* is a most inordinate appetite, entirely disproportioned to the wants of the body. The French have divided this form of disease into *faim de loup*, and into *faim canine*, the latter being distinguished from the former by the gorged stomach relieving itself after every meal by vomiting. Either form of this disease is extremely rare, and its causes unknown, but it generally occurs in the lowest class of persons. When Bonaparte was first consul, he sent to Corvisart a Russian soldier labouring under the *faim de loup*, and to whom it was equally indifferent what he ate, but he required every day forty pounds of meat and bread, or its equivalent, two bushels of potatoes. He daily drank, also, fluids to the amount of twenty-five pints. Leroux gives an account of a man named Bogén, the keeper of wild beasts to the Jardin du Roi, who had a similarly enormous appetite, and to whom it was equally indifferent what kind of animal he ate, whether it was fresh or putrid, killed in a state of health or had died of disease, raw or cooked. He is said to have eaten up a rhinoceros, an elephant, and several lions and tigers. He at length fell ill, and was brought to La Charité, where he not only ate up all that remained of the patients' food; but Leroux even saw him devour the poultices as they were taken off their sores. The patients who have died of this disease have been found to have singularly enlarged stomachs, hanging down like a pouch. They seldom live long or enjoy good health.

Several cases of the *faim canine* are given in the "Philosophical Transactions." One, a boy that lived at Blane Barnesley, in Yorkshire, and only twelve years old, who devoured 384 lb. of solid and liquid food in six days; but after every meal he vomited. In another similar case, 371 lbs. were eaten in the same short space of time, but he also vomited so that he was literally starved in the midst of his abundance.

*Anorexia* is the opposite extreme to bulimia, and is a loss of appetite, accompanied by most feeble powers of digestion. Anorexia occurs to a greater or less extent in almost every case of acute disease; and occasionally also it occurs as a primary disease, and to such a degree as to have acquired for the patient the reputation of the "fasting woman." Among the many instances of this class is the celebrated Anne Moore, the "fasting woman" of Tuthury. This person was fifty-one years of age, and gave out she had not tasted any solid food for five years, nor any liquid for nearly four years, and had no desire for either; that she never wetted her lips but when she washed her face, which happened only once a week; that she had voided no urine since Easter three years, and no fæces since that day five years. She professed also never to sleep so as to forget herself, nor to have lain down in bed for more than three years, although she admitted she sometimes dosed and reclined her head on a pillow. By this remarkable story she obtained great notoriety and much money, and was continuing to practise on the public credulity when it was determined to prove the truth of her assertions by setting a watch over her. The first watch was wanting in closeness of observation, and proved unsatisfactory, but enough had been seen to arouse suspicion. A second watch was therefore proposed, to which she assented most reluctantly. This second watch was superintended by three magistrates, four physicians, twenty-eight surgeons, and fifteen clergymen of the Church of England, who attached a Merlin's weighing-machine to the bed, and took every precaution to detect imposture. Up to the tenth day she did not take any nourishment, but the machine showed a loss of weight of many ounces. She now fell into syncope, from which she was recovered by administering some nutriment, when she confessed she could not exist without some food, as milk or tea, into which her daughter admitted she sometimes put sugar.

*Abstinentia*, or starvation, is the last degree of anorexia. Some persons fall into this state from cancer or stricture of the œsophagus; some from insanity, and a few others from the ordinary accidents of life. If the party be deprived altogether of fluids, he generally falls in three or four days, or at most within a week. A person, however, will live much longer deprived altogether of solids, provided he is able to obtain fluids.* The longest fast perhaps on record occurred in Dr. Willan's practice, who attended a religious monomaniac who had lived sixty-three days on a pint of water flavoured with a little orange-juice daily. From the histories of these cases it appears that the sensation of hunger ceases about the third day, and that when the fast is much prolonged beyond this period the party becomes querulous and subsequently outrageously mad. When Captain Franklin undertook his perilous journey to the North Pole, his party, during their extreme privations, were sensible of each other's pettishness and irritability, and wondered, if they lived to return to England, "whether they should recover their senses." When the Medusa, a French frigate, was wrecked off the coast of Africa, and the crew had betaken themselves to a raft, they fought battle after battle, throwing each other overboard, and all this without any object. Of the small number saved, one officer had so far lost his senses, that the night he was rescued he attempted to throw himself out of one of the ports of the vessel, to take a walk, as he said, in the green fields.

The pangs of hunger are, in the first instance, merely a neurosis of the nerves of the stomach; but it seems probable that after a time they become the exciting cause of a low inflammation; for we uniformly find, in cases of long inanition, whether from disease or accident, that the mucous membrane of the stomach is of a deep venous red or brown colour, and covered with a glairy mucus. It is this highly congested state which in all probability renders a minimum quantity of the lightest kind of diet, as a few occasional spoonfuls of milk or broth, alone proper in the first few days for the recovery of the famished patient. It is universally observed that any dereliction of this rule is generally fatal.

*Polydipsia* is an inordinate thirst—a disorder concomitant with many complaints, but which is also sometimes idiopathic. A small tradesman was admitted into the Hôtel Dieu with a sprain of the knee, when his uncommon thirst attracted attention. It was ascertained that he had been affected with polydipsia ever since he was five years old, and that from the time he was sixteen he had never drank less than two buckets a day. While

* In M. Chossat's experiments, rabbits were found to live one-fifth longer when allowed water *ad libitum*.



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he remained in the hospital he never drank less than thirty-three pints daily, often swallowing two quarts at a draught; his solid food was about one pound and three-quarters daily. This patient soon recovered from his accident, seemed in good health, possessed the strength of ordinary men of his age, and was the father of several children.

*Emesis*, or vomiting, has many grades, or from nausea till nothing is retained on the stomach. It is often a consequence of most structural diseases of the alimentary canal, but it is likewise often purely functional. Young children sometimes suffer from it. Patients labouring under phthisis, or severe cough, or under structural disease of the liver or kidney, young women with an irritable uterus, and pregnant women, are more especially afflicted with emesis. Many hysterical women appear to vomit "par habitude." Pinel gives the case of a lady, aged thirty-seven, who, in consequence of some domestic chagrin, forsook the "grand monde," fell into a state of melancholy, and at length was seized with an obstinate and long-continued vomiting, of which she died. The stomach and intestines were perfectly healthy. The treatment of this form of disease is effervescing mixtures, mild cathartics, opiates, and mustard poultices.

Such is a short outline of the simple neuroses of the stomach, unaccompanied by any determined morbid secretion. The treatment of all these forms is extremely difficult, and resolves itself into attention to the general health, and to regulating the bowels by mineral waters, neutral salts, rhubarb, castor oil, opiates, and mild tonics.

The class of neurosis of the alimentary canal, accompanied by some morbid secretion, is composed of cholera vulgaris, cardialgia, pyrosis, and pneumatosis.

*Cholera vulgaris* is a severe gastralgia, accompanied by vomiting, and very often by purging, but not necessarily so. This disease is most common towards the close of summer and the beginning of autumn, but is by no means confined to that season. Its remote cause is probably, in many cases, some ephemeral atmospheric poison, and perhaps still more commonly a large quantity of autumnal fruit, or of early oysters. All ages are liable to it; infants, children, adults, and aged persons; but men are perhaps more liable to it than women. Many persons have died of it, and, on inspection, no trace of disease has been discovered in any portion of the alimentary canal, or other part of the body.

The symptoms are, that the patient, perhaps having dined or supped heartily, is awoke in the middle of the night with a severe pain in the stomach and bowels, which shortly afterwards is followed by vomiting and purging. In hot climates large quantities of bile are said to pass upwards and downwards, but in this country bile in any quantity is rare. Much more generally the matters vomited are merely the contents of the stomach, half digested, and extremely acid; while the stools, though sometimes dark, as in ordinary diarrhœa, are often white and colourless. This affection lasts from a few hours to a few days, is extremely exhausting, and if neglected has often proved fatal.

In prescribing for cholera vulgaris, we should look to the state of the tongue; and, if it be white and coated, the treatment is by an opiate, effervescing draughts, or mild purgatives. If, on the contrary, the tongue be clean and the bowels purged, the purgative may be omitted, and the treatment trusted to a mild opiate, as the syrup of poppies, or the pulvis cretæ compositus cum opio ℈j. to ʒſs. ex. aq. menthæ pip. 6$^{ta}$ vel 4$^{ta}$ horis. The diet should be slops and light puddings, and the drink perhaps weak brandy and water.

*Cardialgia* is the secretion of a fluid abnormally acid by the stomach, causing a most unpleasant sensation about the cardiac orifice, and hence termed *heartburn*. This fluid is often regurgitated into the mouth, has a most disagreeable oily acid taste, and not only sets the teeth on edge, but, expectorated on any carbonated alkali, causes effervescence; and by Dr. Prout is supposed to be principally lactic acid. The effect of this state of the stomach is both present and remote. The present effects are more or less pain in the stomach, accompanied by distressing flatulence, derangement of the bowels, headache, terrifying dreams. The remote effects of this disease are, inducing palpitation, gravel or stone, or else a gouty or rheumatic state of the constitution, or *uric acid diathesis*, for the urine is loaded with the lithates, and the water small in quantity. This state of things, Dr. Prout seems to think, may be caused by an absorption of the acid, the assimilation in the lacteal system being most imperfect.

This disease most commonly occurs in those that live high, eat largely of rich black meats, and drink largely of malt liquors or champaigne, which act as ferments, turn acid, and dispose everything else to undergo the same changes. Some persons, especially those descended from gouty or rheumatic parents, have an idiopathic tendency to this disease, and in these the most opposite substances will produce it, as sub-acid fruits, salt meats, pastry—indeed anything that deranges their enfeebled powers of digestion. Tobacco has a poisonous principle which greatly favours the occurrence of this disease, and many persons suffer after smoking a very few cigars.

The treatment of cardialgia is by alkalies selected according to the state of the patient's bowels. If constipated, the sulphate of magnesia is perhaps the best remedy; on the contrary, if they be natural, the carbonate or bicarbonate of soda or potash is to be preferred: while, if relaxed, some mild opiate should be added to any of these medicines. Many practitioners prefer magnesia, but this is objectionable on account of its tendency to accumulate and concrete in the intestines. This disorder, once removed, is often prevented recurring by a dinner pill, as five grains of rhubarb, or as many grains of the pilulæ aloes comp., or other gentle purgative.

The dietetic treatment is of the utmost importance in these cases; and the quantity of wine or other fermented liquor, and also of animal diet, should be reduced till the disease subsides and the urine is healthy. Soups, tea and coffee, drank, as they usually are, boiling hot, debilitate the coats of the stomach, and tend consequently to produce this affection, and are abandoned by many persons from their so often exciting cardialgia.

*Pyrosis* (πυρόω, to burn).—Water-brash, *fer chaud*, is a painful disorder of the stomach, occurring in paroxysms, and which does not cease till the patient vomits up a limpid colourless fluid like water, to the patient's taste cold and insipid, but which sometimes gives an acid and sometimes an alkaline re-action.

This disease is frequently met with in Scotland and in Ireland; and Linnæus says one-half of the inhabitants of Sweden are liable to it. From the large quantities of spirits drank in those countries, it has been supposed to be caused by their immoderate use. Dr.

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Pemberton, however, was convinced, after the minutest investigation, that this opinion was erroneous. "For had the disease arisen from the intemperate use of spirits, we should expect to find it most frequent among men, who are more addicted to immoderate drinking than women. On the contrary, I find," he adds, "that the disorder is more frequent among women than men, in the proportion of five to one. I must remark, moreover, to show how unfounded is the opinion respecting the use of spirituous liquors being the cause of the disease, that the women in the north of Ireland are remarkably temperate in their own country; and again, that the same order of women, when they are brought to this, and contract the pernicious habit of drinking spirits, are free from this complaint." This affection seldom occurs except in those who live upon a low and insufficient diet.

The fit of pyrosis usually comes on in the morning and forenoon, when the stomach is empty. The first symptom is a sense of constriction, as if the stomach was drawn towards the back, while others describe it as a severe and often a burning pain. This gastrodynia, as in fact it is, the patient finds increased by standing or sitting upright, and therefore he seeks relief by bending his body forward and making pressure on the affected part. The attack lasts from a few minutes to the greater part of an hour, when a clear, limpid, tasteless fluid is vomited up, varying in quantity from an ounce to a pint. As soon as this fluid is rejected the pain ceases, and the paroxysm is at an end. The paroxysm may occur three or four times a day, but when there is only one, it usually comes on before ten o'clock in the morning. In addition to the paroxysm, the patient's appetite is generally impaired; he complains of thirst, his bowels are generally constipated, and his person pale and emaciated.

The medical treatment of this affection is extremely simple, and consists in a drachm of the sulphate of magnesia, with fifteen minims of the tinct. hyoscyami three times a day. Many other medicines have been recommended, as the tinct. kino by Dr. Pemberton; but the simple remedy that has been mentioned is so uniformly successful as hardly to require any auxiliary or substitute. The diet should, if possible, consist of some animal food, and be otherwise nourishing.

*Pneumatosis.*—The stomach and intestines have the property of secreting gases, probably for the purpose of preventing that collapse of those hollow organs which perhaps would otherwise ensue. The gases found in the alimentary canal are oxygen, azote, proto-carburetted hydrogen, carburetted hydrogen, carbonic acid, and sulphuretted hydrogen. The two first are probably derived from the atmosphere, but all the rest are supposed to be secretions. All these gases, except the last, are found in the stomach, small intestines, and colon, but the sulphuretted hydrogen is found only in the colon, and then in extremely minute quantity.

The secretion of these gases is often a disease of much inconvenience, causing not only great distension, but also often much pain, forming *windy colic*, or pneumatosis. It always marks a feeble diathesis, and is a constant accompaniment of asthma and nervous affections of the heart, and also of every hysterical disease. It is one of the alarming symptoms also of typhus, when it causes tympanitis. If it exists idiopathically, it is best met with warm aromatic tinctures and purgatives, as the tinct. cardamomi, the tinct. aurantii, the decoctum aloës comp., rhubarb, and strong waters, as aq. cinnamomi, or the aq. menthæ piperitidis.

### Of the Neuroses of the Intestinal Canal.

The principle neuroses of the intestinal canal are enterodynia or colic, ileus, constipation, and diarrhœa.

*Enterodynia, Enteralgia, Colica*, or bowel colic, is a painful affection of the lower portions of the abdomen, caused by a violent contraction of the muscular fibre of some portion of the intestinal canal. The remote causes are indigestion, exposure to cold, or other general cause, and the parties liable are of all periods of life, or from infancy to old age. It also attacks either sex.

It is seldom that persons die of colic, but such instances have occurred, and dissection has often shown some portion of the intestines intussuscepted, affording a strong presumption that this affection depends on a spasmodic constriction of some part of the intestinal canal. This view of the case is supported by Mr. Blane, who states that in fatal cases of colic in horses, different portions of the alimentary canal are found strongly contracted, and much oftener of the small than of the large intestines, which also sometimes contain gas. The bladder also appears to participate in the spasm, the urine being either frequently ejected or else suppressed. Colic, therefore, is a spasmodic contraction of the intestines, the muscular fibre being either primarily or else secondarily affected in consequence of a morbid sensibility of the mucous membrane.

Colic is usually sudden in its attack, and the patient consequently, without any previous indisposition, is often unexpectedly seized with a severe fixed pain in some part of the abdomen, but which is relieved on pressure, so that the patient either sits doubled up or else rolls on the ground. In other cases, where much air is secreted, the bowels are greatly distended, and the pain is now compared to a twisting or wringing pain around the navel, accompanied with soreness. The walls of the abdomen also participate in the internal spasm, so that the navel is often drawn in towards the back, or the heads of the rectus exceedingly prominent, resembling so many round balls. The bowels are generally but not always constipated, and the stomach may or may not be irritable. In the latter case it often rejects both food and medicine. The pulse is little altered at the commencement of the attack; but if the paroxysm be prolonged, and the patient exhausted by pain, it may be hurried and frequent. The tongue is generally clean, although sometimes white and coated.

*Diagnosis.*—This disease is distinguished from inflammation by the pain being relieved on pressure, and by the quiet state of the pulse.

*Prognosis* is, in every case, favourable.

*Treatment.*—The treatment of colic is by opiates, stimulants, and purgative medicines. When the bowels are very constipated, five grains of calomel, fifteen grains of jalap, and one grain of opium should be administered immediately, and followed by mist. camphoræ c. magnesiæ sulphatis ℥j. c. tinct. hyoscyami ♏xv. to xx. c. tinct. cardamomi, ʒj. 4^{ta} vel 6^{ta} horis, until stools are obtained. In mild cases a scruple of rhubarb, or half an ounce of castor oil or other mild purgative, combined with a grain of opium, may be substituted for the opium, calomel, and jalap. Some practitioners have doubted the propriety of exhibiting opiates at the onset of the disease, but it is certain a mild purgative, combined with a mild narcotic, as the tinct. hyoscyami, or syr. papaveris, will

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affect more than a drastic purgative without such combination.

As the disease is sometimes confined to the large intestine, enemata often give immediate relief. Externally, the application of large bags filled with hot chamomile flowers, or of heated sand, or of the stomach-warmer filled with hot water, are useful. The warm bath, fomentations, or a large linseed or mustard poultice over the abdomen, are also highly useful auxiliaries. Some patients are said, when these remedies have failed, to have been benefited by dashing cold water over the lower extremities; but the experiment is hazardous. The diet should, during the attack, be slops, as sago and arrow-root, with a portion of brandy; and for some time after the patient has recovered it should be light, and, perhaps, limited to fish and puddings.

*Ileus, Miserere Mei, Volvulus*, is a severe variety of colic, accompanied by vomiting, often so obstinate that the action of the bowel is inverted, and fæcal matter thrown up by the mouth. The patient may or may not be constipated. The returns for 1839 show 639 deaths from colic and ileus in England and Wales.

This inversion of the action of the intestine is often the result of inflammation, of cancer, or of other structural disease of the intestine; but it sometimes occurs idiopathically, and especially in broken and feeble constitutions.

Its more frequent cause, however, is some mechanical obstruction; and it is singular in how many different ways this may be produced. In some instances a portion of intestine has slipped into a loop, formed by a band of adhesion, which has united the folds of the intestine to each other, or to the walls of the abdomen, or to some other part. The colon also has been found to have taken a round turn on itself, or the right portion to have passed over to the left side, or left portion to the right side. Adhesions of the omentum, or of the appendix vermiformis, have likewise formed a similar loop or noose, and the intestine has been strangulated in it. Sometimes an accidental opening, acting as a noose, has existed in the omentum or mesentery. Ileus, from the intestine being strangulated in the various forms of hernia, is common. The accidental insertion of one portion of intestine into another, termed intussusceptio, is another cause. In one case, more than 18 inches of the ileum had passed into the caput coli; and in another, the small intestine protruded at the anus. In some few cases the intussuscepted portion has sloughed away, and yet the integrity of the canal has not been impaired. An ulcer of the colon has also communicated with the stomach, and in this manner ileus has been produced.

The following case, quoted from Dr. Abercrombie, will show that ileus is in many instances entirely functional:—A man, aged 40, had violent pain of the abdomen, urgent vomiting, and obstinate costiveness. The pain was at times increased on pressure, but not uniformly so; and his pulse beat at first about 96, but at length rose to 120. The attack had commenced with symptoms resembling cholera, which had speedily passed into those of ileus. After his death a large portion of the small intestines was found in a state of great and uniform distension, without any appearance of inflammation; and, except the lower part of the right lobe of the liver being unusually soft, no other morbid appearance could be discovered on the most careful examination.

It has been debated whether, in cases of stercoraceous vomiting, the fæcal matter proceeded from the small or large intestines. It is certain, however, that the contents of the small intestines take on the character and odour of fæces—a fact unknown to the older physiologists, and even to Mr. Abernethy. The matters vomited, therefore, for the most part proceed from the small intestines, and only occasionally from the large.

Ileus sometimes comes on in the course of a disease which at first presented no very formidable symptoms. As soon, however, as the stercoraceous vomiting is established, the powers of the patient rapidly sink, and a few hours, two or three days, or at most a week, generally terminate his sufferings. In cases of ileus caused by a mechanical obstruction, pain, increased on pressure, and often of considerable intensity, is present, denoting that inflammation of the constricted part has taken place; and in this case the patient dies in redoubled agony, unless mortification takes place.

*Diagnosis.*—The stercoraceous vomiting distinguishes this from every other disease.

*Prognosis.*—The prognosis is not always hopeless, but is, nevertheless, most grave.

*Treatment.*—Such alleviation as this disease admits of is derived from opium, effervescing draughts, mild purgative medicines, opiated enemata, or mercury and opium by inunction. Popular opinion, which has termed this disease " Lord have mercy upon us," seems to consider it entirely beyond the powers of medicine. Instances, however, have been met with in which the patient has been recovered. Pinel, for example, mentions a case in which the matters vomited were supposed to be decoctum malvæ, which had been thrown up the rectum half an hour before, and yet the patient did well.

When ileus depends on a mechanical cause, the intestine sometimes rights itself; otherwise, neither art nor medicine afford relief.

*Diarrhœa* is a discharge of frequent loose watery motions; and there is hardly any agent, moral or physical, that acts on the human body, that is not capable of producing it. The passions, heat or cold, changes of weather, changes of wind, or any unusual indulgence at table. Many known morbid poisons, and probably many ephemeral ones, not yet determined, are also its frequent cause; and so general is this disorder, that every age is liable to it, as likewise either sex, and, perhaps, in nearly equal proportions.

Many opportunities present themselves of examining patients who have died of diarrhœa; but often not the slightest appearance of inflammation or other structural disease in any part of the alimentary canal can be found. It is consequently in a great number of cases a disease purely functional.

Some speculations have been entertained as to the seat of diarrhœa, or whether it results from a diseased action of the small or the large intestine. From the quantity of fluid occasionally found in the small intestine, there is no question of that portion of the alimentary canal being often the seat of diarrhœa. In other cases the colon is, perhaps, in like manner exclusively affected; but probably it is more common that both portions are simultaneously affected.

In diarrhœa the fæcal discharge often deviates from health, not only in consistency, but also in colour, being sometimes white or clay-coloured, or else green or black; and the question arises whether this discoloration is owing to a diseased state of the bile, or to the morbid secretions of the intestinal canal; and it may be affirmed to be more often owing to the latter than to the former.

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Elementary Principles of Medicine.

In diarrhœa the bile is, perhaps, often faulty; but on examining the bodies of those who have died of this complaint, we often find the bile in the gall-bladder healthy, and also the matters contained in the duodenum healthily coloured with bile; but in the lower portions of the intestines one portion of the fæcal matter may be white, another green, and, perhaps, another natural; the colouring matter of the bile having been discharged or otherwise acted upon by the secretions of the intestine; and sometimes the fæcal matter is of a healthy yellow colour in the small intestines, and green or white throughout the whole extent of the large.

*Symptoms.*—In diarrhœa the stools are frequent and watery, and sometimes mixed with blood; often accompanied by flatulence, and by pain more severe immediately before passing a dejection. Their number is very various, or from three or four to thirty or more in the course of the twenty-four hours. They are generally copious; and Morgagni states, that in his own case he once passed 16 lbs. in a very few hours. The duration of the disease varies from a few hours to many months.

For practical purposes idiopathic diarrhœa is divided into two kinds, or into that in which the *tongue is clean*, the pulse quiet, and all constitutional re-action absent; and again into that in which the *tongue is white* and coated, the pulse accelerated, some fever present, and the pain or soreness constant, and increased by pressure. The stools in either case may be black, green, white, or mixed with blood indifferently.

*Treatment.*—When the *tongue is clean*, if the disease be quite incipient, the most usual practice is to give one dose, consisting of an opiate, combined with a gentle cathartic, as opii gr. j., c. pulv. rhei ℈j., to remove any offending matter that may be present. These medicines having produced their intended effect, we may now exhibit medicines more distinctly astringent. In many cases a drachm of syrup of poppies after each stool is sufficient. In severe forms of the disease, aqua menthæ piperitidis ℥ ſs. c. pulv. cretæ comp. c. opio ℈j. to ʒ ſs. every four or six hours, is an excellent prescription; and these medicines may be used whether blood be or be not in the stools. If the opiate and aromatics contained in the above medicine should prove insufficient, it may be necessary to add to each dose some of the class of pure astringents, as a drachm of the tinct. kino, or catechu, or hæmatoxyli.

There are cases of diarrhœa with a *clean tongue*, which will not yield to opiates, astringents, or stimulants, either singly or combined, and which probably depend on a want of tone in the intestine; and in these cases five grains of salicine every four or six hours have often stopped a diarrhœa that appeared fast hurrying the patient to his grave.

When diarrhœa is accompanied by a *white furred tongue*, together with pain and soreness, it is necessary to exhibit opiates, combined with some mild purgative. Thus aqua menthæ c. magnesiæ sulphatis ʒ ſs. to ʒ j., with a drachm of syrup of poppies; or 15 minims of the tinct. hyoscyami; or, in severe cases, with iij. to v. minims of tinct. opii $4^{tis}$ vel $6^{tis}$ horis, are remedies on which, as a general principle, we may very confidently rely. In other cases rhubarb, castor oil, or any other mild purgative, may be substituted for the Epsom salts. In cases of diarrhœa, accompanied by vomiting, a drachm of syrup of poppies, *neat*, repeated every half hour or every hour for two or three times, often quiets the stomach, and enables it to bear the other remedies; or soda water, or the effervescing draught, with a table spoonful of brandy, with or without a few minims of tinct. opii, often remain when every thing else is rejected.

Most practitioners lay great stress on the colour of the stools, and the necessity of correcting the supposed morbid states of the liver; but it has been shown that the various colours of the stools are caused rather by morbid secretions from the surface of the mucous membrane of the intestines, than by any defective state of the bile in the gall-bladder; and the conclusion from this consideration is, that in simple diarrhœa mercury in any form is either unnecessary or injurious in the great majority of cases. In a smaller number, however, it is sometimes necessary, and more especially in children under four years of age. One general law may be said to be established in the cure of diarrhœa, which is, that in the adult, whatever be the form of the diarrhœa, if the stools be dark at first, and then become light coloured, purgative medicines are no longer beneficial.

The dietetic treatment should be limited to slops, puddings, and white fish, and the drink to weak brandy and water, which acts locally as an astringent, and generally as a diffusible stimulus.

*Constipatio* is a retention of the stools beyond the usual period, so that when they are passed it is with difficulty, and comparatively in a hard indurated state.

*Remote Causes.*—The remote causes of this affection are extremely numerous. Every form of indigestion, for instance, may be a cause of constipation. Hæmorrhoids, or piles, is another frequent cause; as well as a too sedentary life, especially if too strictly applied to study. Also women labouring under amenorrhœa, or other functional disease of the uterus, have often constipated bowels; and almost every acute disease is occasionally ushered in by constipation. It is likewise a common concomitant of most chronic affections, as dropsy, diabetes, hydrocephalus, pyrosis, rheumatism, or mania. Many articles of diet are causes of constipation, as brandy; many mechanical accidents, also, as stricture of the alimentary canal; many medicinal substances, as lead, opium, or other astringent, are all causes productive of constipation.

*Predisposing Causes.*—Persons of all ages are liable to this affection; but it is most common, perhaps, after the middle periods of life. Both sexes suffer from it; but women, from their more sedentary lives, the greater capacity of their colon, and their greater delicacy on these subjects, are most disposed to it. When pregnant, it is a frequent complaint with them, as some suppose, from the pressure of the enlarged uterus on the colon.

*Pathology.*—This disease is essentially a disease of function, and often exists without the slightest trace of organic lesion. Its physiological cause appears to consist in want of sensibility of the nerves of the mucous membrane of the alimentary canal to the stimulus of their ordinary fæcal contents, so that the peristaltic motion downwards is retarded. It has been a question in what portion of the alimentary canal constipation takes place; and most authors have placed its seat exclusively in the large intestines. In posthumous examinations however, formed, lumpy, hardened fæcal matter is sometimes found in the small intestines; and hence it is manifest that the seat of constipation may be either the small or the large intestines, and, perhaps, most frequently in both.

*Symptoms.*—It is a law of the animal œconomy that most persons in health have one evacuation daily, and

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at the time when the organic sensibility is heightened by repose, as on getting up in the morning; or when it is excited by a meal, as after breakfast. If this period be prolonged the fæces become hard, knotty, or scybalous, and ultimately form large round balls. This retention of the fæcal matter often causes great distension of the abdomen, as well as pain, irritation, and a flow of blood from the rectum on the passing a stool. In some instances the fæcal matter, whether retained in the caput coli or other part of the intestinal canal, causes so much irritation that constipation and diarrhœa co-exist at the same time, the solid matters being retained, while the more fluid portions give rise to repeated stools. A complication often confirmed by the evidence of repeated examinations after death. Such are the local symptoms.

The general symptoms are not less distressing than the local affections. The appetite is in general lost, the head aches, a gloom is cast over the spirits, the mind and body are indisposed to exertion, the temper is soured, and every pleasure of life embittered. The effects of constipation are so well known, that in some courts it is said to have been a rule never to ask a favour till after the monarch's bowels had been freely opened. Besides this general influence of constipated bowels over the healthy state of every function, there are few disorders which are not aggravated by its continuance, and few that are not benefited by its removal, while many are cured altogether. There is, indeed, no rule of health more important than that the bowels be kept regularly and daily open.

Instances of constipation of two, three, four, five, to, perhaps, fifteen days are not rare. A gentleman under the care of Mr. Benjamin Phillips passed thirty-seven days without any evacuation. In a case related by Dr. Willan, of a monomaniac who destroyed himself by a voluntary religious fast, the patient had a stool on the second day of this course, but not again till the fortieth day. An instance occurred to Dr. Williams, St. Thomas's Hospital, and related by Dr. Burne, in which the patient, a lady, had only four stools in a year; while a young lady, aged 18, was attended by Dr. Burne, who passed neither flatus nor fæces for six months.

The quantity of fæculent matter discharged in a state of health is about five ounces; but in cases of constipation the quantity passed at one motion is often quite extraordinary. One case is related by Dr. Warner in which the party, a lady, passed in a short time forty-two lumps, each as big as a hen's egg. In the case of Dr. Williams, the quantity passed at each motion filled a common-sized pail, and consisted of a number of lumps of healthy fæces, each as big as the head of a full-grown fœtus. Indeed, the passage of each lump gave as much pain as if the party had actually brought a child into the world. In some instances the fæcal matter retained collects in the caput coli, and forms a tumor so considerable that it has been mistaken for fungus hæmatodes, or an aneurism.

*Treatment.*—When the constipation is accidental and of short duration, any of the milder cathartics, as the sulphates of soda or of magnesia, castor oil, rhubarb, aloes, or the confectio sennæ, or the pilulæ colocynthidis comp., will in general remove it. If, however, the constipation is habitual, these laxatives should be continued daily for a short period till the *healthy habit* of a daily evacuation be established.

The remedies that have been mentioned, though often successful, yet occasionally fail from the low tone of the sensibility of the mucous membrane of the intestine. In these cases the combination of a tonic with a purgative will often produce a more efficient action than the purgative alone. Thus we often find two grains of the ferri sulphatis, or an ounce and a half of infusi gentianæ, combined with a drachm of the sulphate of magnesia, and exhibited, according to the urgency of the case, three times a-day, or every six hours, will often produce catharsis when the salt alone would fail. In old persons, also, we find that a combination of aromatics with the purgative, as in the decoctum aloës, is a more useful and effective remedy than the same or even a greater quantity of aloes exhibited alone.

When constipation does not yield to the simple treatment which has been mentioned, recourse must be had to larger doses, or else to more active purgatives. Thus calomel, gr. v., c. jalapæ, gr. xv., is a dose which rarely fails even in our public hospitals to produce motions, and this, if necessary, may be followed up four hours after either by the neutral salts in divided doses, or else by a black draught in one dose. If a stronger medicine than the above be necessary, elaterium is of greater power, and one or two grains will sometimes produce hypercatharsis. Elaterium, however, often produces vomiting; and in these cases a drop or two of croton oil is a remedy which may be substituted with success, as it sits easily on the stomach. The catalogue of purgative medicines, however, is large; and when the more powerful medicines are necessary, recourse should at once be had to medical advice.

If medicines by the mouth have been insufficient, it is desirable to hasten their action by enemata. The enemata may be simply a pint of warm water, 100° Fahrenheit; or the same quantity of warm water, with half an ounce of common salt. The common soap enema is likewise a valuable remedy; and when the constipation is great, half a pint to a pint of castor oil, *neat*, may be thrown up.

Sometimes the fæcal matter accumulated in the colon is so large in quantity, and so hard and impacted, that manual assistance is necessary to relieve the patient. "Mrs. W. had suffered for years from constipated bowels; but when I saw her," says Mr. Jukes, "a contrary state of bowels had taken place, she being much harassed by purging, which had existed more or less for many months. At length violent tenesmus came on, with a bearing down most intolerable, much worse, she said, than she had ever suffered in any of her confinements. I examined the rectum, and found a mass of hard matter which I could not break to pieces without the aid of an instrument." The mass consisted of a variety of undigested substances, which, when broken down, were washed away by injections, to the perfect relief of the patient.

*Dietetic Treatment.*—The patient suffering from constipation should avoid port wine or brandy, and should eat freely of sub-acid fruits. The advice of Mr. Locke should also be strictly followed, or that he should go daily at the same hour to stool; for such is the periodical regularity of all the functions of the body, that they are more regularly performed at accustomed hours than at any other time.

Having thus described the diseases of the alimentary canal arising from general causes, it is now necessary to apply ourselves to those arising from specific causes, or from entero-lithates, from worms, from the too abundant use of salt provisions, causing scurvy; also to those

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Elementary Principles of Medicine.

caused by the effects of lead, of alcohol, and of fish poisoning.

### OF ENTERO-LITHATES.

*Entero-lithates.*—This term has been given to the great variety of organic and of inorganic substances which, having been swallowed, are sometimes found either in the stomach or intestines. The organic substances are principally the husk of the oat-cake formed into balls, and which are occasionally met with in the stomach; and also plum or cherry stones. In a youth who died of colic and convulsions, the cæcum was found stuffed with a large number of cherry-stones. In another patient, who died after three years' suffering, the colon was found distended with about three pounds of cherry-stones and about forty lead balls, which he had swallowed in the hope of obtaining ease. When it was the fashion to take mustard-seed as a medicine, these were often passed in large quantities. One gentleman sowed some of them, and they throve well. Dr. Prout saw a lady of title who passed what appeared to be larks' bones.

The inorganic substances are as various as those of the organic kingdom. The eating of pounded glass is not uncommon; and, if broken into small pieces, Chalissièr considered it as perfectly inert, and even large pieces swallowed are often productive of little other inconvenience than a scratch of the throat. Sauvages made dogs swallow bits of glass of various sizes, and with such impunity that he ended his experiments by swallowing some himself, and without any notable accident. Portal saved a young man who experienced alarming symptoms after swallowing fragments of glass broken between his teeth, by first making him eat large quantities of boiled cabbage, and then giving him a vomit.

To swallow pins is a common mode, in some countries, of committing suicide, and the usual mode of getting them down is by enveloping them in wax. Sometimes, also, they are given with an intention of destroying others. In April, 1838, a healthy child of two months and a-half old was seized with a paroxysm of suffocation, and its life appeared to be in danger. The mother, however, on examining what had passed from this child's bowels, found in the first stool three pins, in the second four, and in the last two pins. This child was nursed by a servant girl of weak intellect, who admitted that she had given them to the child in one of those paroxysms of irritation which accompanied her menstrual period.

Pins thus swallowed are sometimes found, as in the above case, in the bowels; in others in the stomach; and sometimes in various other parts of the body. Olivier examined a stone patient, that died after the operation, and found a bent pin making its way through a fold of the mucous membrane of the stomach, which had caused no other alteration than a slight thickening of the part where the pin was lodged. More commonly, perhaps, they make their way either to the surface or to some other part of the body. Dr. Silvy gives a case in which 1400 pins or needles were found implanted in the different muscles or organs of the body in a maniacal girl who died of phthisis. None, however, were found in the lungs. Boisseux has given a similar case of a young woman who, during a delirium of twelve days, swallowed 800 pins, all of which were extracted from the superficies of the body.

But the swallowing of pins is not always free from danger. Arnaud and Saviard found a large pin in the testes, and which had caused carcinoma of that organ. Schenk saw a case which was fatal from a pin having penetrated the liver; and Bayle another, in which a pin had penetrated the ureter, and caused an abscess in that part.

Besides pins, watches, knives, penny pieces, and half-crowns have been swallowed and retained by mountebanks, or polyphagists, as they are termed. One of these swallowed a silver fork, which, being retained, was removed by an incision. Perhaps among the most remarkable of these entero-lithates is an egg-cup found in the ileum of a man by Mr. Deads. The man was sixty years of age, and for several months had suffered from abdominal ailments. He at length died after stercoraceous vomiting, singultus, and great distension of the abdomen. On examining him, an earthenware egg-cup was discovered impacted in the ileum, about ten inches above the cœcum. The ileum at this part adhered to a hernial sac, and prevented its further passage downwards. Another person swallowed a piece of a flute four inches long; but was more fortunate, for it passed by stool three days afterwards.

Sometimes the intestinal entero-lithates are introduced per anum. Dr. Burne relates the case of a lady who, being supposed to labour under a stricture of the rectum, was directed to use a bougie at her own discretion. Being from home, however, and without a bougie, she substituted at bed-time a piece of wax candle, about six inches long, and which, in the course of the night, slipped into the colon. Within a week she was seized with vomiting and bearing down, so severe, that it led to an examination of the rectum, when, in a mass of fæcal matter, and by no means hard, the candle was found broken in the middle, but held together by the wick.

The largest number of entero-lithates, however, has arisen from the concretion of substances taken as medicine. Mr. E. Brande gives the case of a lady who took a tea-spoonful of Henry's magnesia every night, till it was calculated the whole quantity taken amounted to between nine and ten pounds troy. At length her left side became tender; an obscure tumor could be felt; and after much suffering she passed a large quantity of what appeared to be sand. This was thrown away; but the following day she passed another quantity, which, being measured, amounted to two pounds; and subsequently several soft lumps were passed, which, being analyzed, were found to be the sub-carbonate of magnesia, concreted by the mucus of the bowels, in the proportion of about 40 per cent. In another case, in which no magnesia had been taken for six months, yet from four to six pounds were found embedded in the head of the colon. In a case that proved fatal in St. Thomas's Hospital two large lumps of concreted magnesia, each as big as walnuts, were found in the small intestines. Chalk and sulphur have been found concreted in the same manner.

### WORMS—ENTOZOA-INTESTINALIA (εντος ζωον).

Besides dead or inanimate substances, living animals are also occasionally found in the intestinal canal.

The intestinal entozoa are four in number, or the *Tricocephalus dispar*, or long thread-worm, and the *Ascaris vermicularis*, or common thread-worm, or maw-worm, both of which inhabit the large intestine. Again, the *Ascaris lumbricoides*, or round worm, and the *Tænia*, or

tape-worm; and these two last inhabit the small intestines. These worms were known to the ancients, with the exception of the tricocephalus dispar, which Bremser considers first to have been discovered by Morgagni. It does not, indeed, appear to have been generally known till the year 1760, when it was accidentally observed in the cœcum of a child, five years old, by a student at Göttingen, who showed it to Ræderer and Wagler, who traced it afterwards in a considerable number of French soldiers who were stationed in that city, and died of epidemic fever. It appears to be common in Germany, much less so in France, and still more rarely in this country.

The *Tricocephalus dispar* inhabits the large intestines, and principally the cœcum, and is from one inch and a-half to two inches long. Its body is capillary for about two-thirds to four-fifths of its length. This capillary portion terminates in a minute point, which is its head. The male is smaller than the female, and is known by the posterior or thicker portion of the body being spiral, whilst it is straight in the female. The ova are elliptical.

*Oxyuris vermicularis, ascarides*, from ἀσκαρίζειν, to leap, or *maw-worm*, has two sexes; the male, according to Bremser, being from a line to a line and a-half long; while the female is from four to five lines long. Their heads are obtuse, vesicular, and traversed by a tube which is the alimentary canal. These worms augment in size from the head to the termination of the anterior third of the body; and from that point they decrease till they terminate in a point scarcely perceptible even by the aid of a microscope. The tail is spiral in the male, and straight in the female.

Bremser and Rudolphi are satisfied that these animals are oviparous. Their abode is in the large intestines, and especially in the rectum, where they often occur in large numbers, to the amount of many thousands. They take their popular name (ascarides) from their head being in perpetual motion, and from their great general activity; so much so that they sometimes find their way into the vagina, when they cause intolerable itching. Frank has also found them in the urethra. They are most common in childhood, but no age is exempted. Cruveilhier was consulted by a man, upwards of fifty, horribly tormented with them; and Bremser by an old man, upwards of eighty, and who continued to pass them till his death.

The *ascaris lumbricoides*, or *round-worm*, is from two to three lines in diameter, from six to fifteen inches in length, is attenuated at both extremities, is generally of a reddish brown colour, and has a small sulcus or groove on each side, which extends the whole length of the body. The head is distinguished by being rather smaller than the tail, and by being surmounted by three valves, which, being opened, bring into view a small tube, which is the mouth. The two sexes are separate, and the male is known by the greater tapering of the tail, which is incurvated, and by the male organ having a double spiculum. The oviducts of the female can readily be seen through its transparent membranes, and appear to fill nearly the whole body. This worm is also oviparous.

This worm inhabits the small intestines, although it is sometimes found passing upwards to the mouth and downwards to the rectum. They have consequently been known to make their way into the œsophagus, and to creep into the nares, and even into the larynx, trachea, and bronchi. The biliary ducts of the liver have been seen full of them; they are said also to have been found in the gall-bladder and pancreatic ducts; and Laënnec states he once saw not only a great number of ascarides in the stomach of a child, but also in the pori bilinrii, which was full of them, while the liver looked as if it had been gnawed by them. They have also been known, in passing downwards, to get into the appendix cæci, also to escape through ulcerated openings into the cavity of the abdomen, or into the bladder and vagina; and, by means of an external fistulous opening, through the walls of the abdomen.

The number of ascarides found in any individual in this country seldom exceeds one, two, or three; but Dall' Olio tells us he threw up, in the course of a fortnight, 450 of them. Marteau de Grandvilliers knew a soldier who passed 367 in six days; and Dr. Hooper speaks of a girl, only eight years old, who voided upwards of 200 in a week. Frank knew of a case where eighty of them, rolled up as a ball, were expelled *en masse*, and alludes to another where the intestines, both great and small, were stuffed with them.

The *tænia*, or *tape-worm*, has a head so extremely small that it is hardly visible to the naked eye, and possesses a power of contraction so great that it sometimes appears long and narrow, and sometimes broad and short. This head has also four suckers (*soupoirs*), which are sometimes prominent and sometimes retracted; and, when the head is elongated, we see between the four suckers a protuberance or disc, on which is sometimes observed a double row of little crochets; but, as they are not always present, Bremser thinks this crown of crochets is lost by age.

The neck of the tænia is flat, of variable length, and without articulations. This unarticulated neck is joined to an articulated body, of which the first joints are narrow, and always broader than long. Towards the more central parts of the animal they are square; and after this they form oblong parallelograms, whose length greatly surpasses their breadth.

On the edges of the articulations, in some individuals at least, are seen two white lines, placed one over the other, and which extend along the whole body of the animal. These lines Rudolphi considers to be the alimentary canal, and to derive their origin from the suckers in the head. At each corner, also, of the best-developed articulations are sometimes seen small papilliform protuberances, each having a very visible foramen in the centre. These foramina were formerly supposed to be so many mouths, but modern naturalists consider them as so many oviducts. The male organs of the tænia have not yet been discovered.

The breadth of this worm varies much. The head is frequently not more than one-half to one-third of a line in breadth; but it gradually augments till its breadth equals three, four, and even six lines. The thickness of the tænia also varies much; some are thin and almost transparent, while others are thicker and more fleshy.

"Nobody," says Bremser, "has, I believe, seen an entire tænia, or one at once provided with a head and a tail, for it constantly happens that the last articulations, which are usually loaded with fœcundated eggs, are detached, and evacuated by stool, before those nearest the head are completely developed; and for this reason we cannot correctly determine the length this worm attains, nor the number of articulations of which it is composed. The length of the tænia, however, is very great; and tæniæ of twenty-four feet long are not un-

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common. Robin found, in the dead body of a man who had recently passed a portion of it many feet long, a tænia which he estimated at thirty feet. The early writers make mention of tænia of much greater length; as Reinlein, one of between forty and fifty aunes. Pliny mentions one of 300 cubits; and, in the Dissertations of Copenhagen, one is related as having been 800 aunes long; and, if this be true, supposing the aune to be only twelve inches long, the worm must have been coiled up twenty times, from one end of the intestine to the other, forming a mass which would destroy all peristaltic motion.

Naturalists possess no satisfactory information of the reproduction of tænia. The articulations being similar to each other has induced many persons to consider them as so many distinct animals, generated one after the other, and connected together; but this opinion is no longer entertained. Blumenbach and Bremser affirm that the worm is a complete animal at birth; the articulations of the tail being first developed, and even detached, before the anterior articulations are yet visible, or only form a kind of elongated neck. The age which the worm attains, as well as the time necessary for its perfect development, are not yet determined.

"The motions of the tape-worm, whether whole or after division, are often," says Rudolphi, "most active; and people in whom it exists are sometimes conscious of its undulatory and disagreeable movements; and portions of many feet are said to have been protruded and afterwards drawn up by the mere effort of the animal. The habitat of this animal is the small intestine. There are said to be many different species of it.

*Remote Cause.*—As these intestinal entozoa differ from any known earth-worm, they are considered to belong to the class of parasitic animals. As all of them exist either in fish, in the ox, in the sheep, and in the animals generally which we use for our diet, it seems possible that the ova may be introduced with our food, the incubation being only perfected in those persons whose morbid state of the intestine affords them a fit nidus, or a large quantity of mucus.

*Predisposing Causes.*—Worms of every description are more common in childhood than in adult age; and in the leucophlegmatic child of weak digestion, than in the strong and healthy. The same temperament also favours their development in the adult. As a general rule, they are common in proportion to the quantity of vegetable food on which the party lives, that diet favouring the secretion of mucus, which is the nidus of these animals. From this circumstance, perhaps, they are more common in France than in this country; in Egypt than in France; while in the East Indies, where the Hindoo lives on rice, nine persons out of ten are infested with these animals.

*Pathology.*—The portion of intestine inhabited by the worm is sometimes a little redder than usual, and sometimes paler, and is generally loaded with mucus, in which these animals delight to live. It has been supposed that the worm possesses the power of perforating the intestine, or even the substance of the liver; but they have no organ fitting for this purpose, and appear incapable of injuring the intestine otherwise than by their perpetual motion.

*Symptoms.*—The existence of worms in *the colon* (as the ascarides) seldom gives rise to much inconvenience until they are sufficiently numerous to pass with the stools. About that time the patient is troubled with much irritation of the rectum, with itching, and often bleeding from the nose, with headache. His bowels also are either constipated or relaxed, the stools exceedingly dark or white, his appetite sometimes lost and sometimes voracious, his sleep disturbed, and his temper fretful; and often, as a result of so many combined irritating causes, remittent fever.

The symptoms of the existence of worms in the *small intestine*, as the tænia and lumbricoides, are often exceedingly obscure, and simulate many other diseases; so that, until a patient has passed a worm or a portion of a worm, we are unable, with any certainty, to predicate its existence; and at no time till we actually see the worm can we determine its species.

The general symptoms of worms of the small intestines are occasional colic, a variable state of bowels, capricious appetite, and headache. The mind is also often so much depressed as to amount to hypochondriasis. Thus, Krause gives the case of a young man who, when troubled with worms, was always seized with uncontrollable fits of laughter; and Giraud an instance of a young man who, under similar circumstances, felt an entire impossibility of walking over anything whatever, even so slight a substance as a piece of white paper; or, if he attempted to do so, he fainted. Hufeland mentions a case in which the patient, without being jaundiced, saw everything yellow; Delisle another that could not bear the sound of a musical instrument. And cases in which St. Vitus's dance, epilepsy, and convulsions have been the prominent symptoms, are by no means infrequent.

When lumbricoides and tænia pass from the small into the larger intestines they are speedily evacuated, and the symptoms are alleviated. When, however, a lumbricoides passes upwards, the symptoms are more marked. In general, the worm is little troublesome till it reaches the upper part of the pharynx, when, either by irritating or getting into the glottis, it often gives rise to a most fearful sense of suffocation. It commonly, however, continues its upward progress till at length it makes its exit, by the assistance of the patient's finger, either through the mouth or nose.

*Treatment.*—The habitat of the ascarides being for the most part a collection of mucus, the means used for their expulsion is generally some sharp purgative medicine, as two grains of calomel and ten grains of jalap, or as many of scammony, exhibited two or three times a-week. It ought, perhaps, in no instance to be given oftener, for if the purging be continued the intestine is weakened and more mucus secreted, so that the predisposition to harbour them is increased. In weakly children, small doses of Epsom salts will ultimately effect the same object, and with less distress to the patient. Many persons place great confidence in calomel, as a medicine capable of destroying them, but it does not appear to act beneficially except as a purgative, and consequently it is an auxiliary, and not by any means the most valuable part of the treatment.

From the ascarides being situated so near the rectum, enemata have at all times been much used in these cases; and injections of oil have been much commended, and especially of castor oil. But these animals, having no respiratory organs, will live from thirty-six to forty-eight hours in castor oil; from the same cause, tobacco glysters have failed. Indeed, very little benefit has been derived from any local treatment. Warm-water injections tranquillize the intestine, and



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perhaps give more relief than anything else. The ascarides are killed by cold; but it is hardly safe to throw a cold injection into the colon of a child.

For the ejection of tænia or the lumbricoides from the small intestines, a great many remedies have been recommended; but, in the present day, practitioners very generally limit themselves to one or two methods, or to a sharp purgative. The celebrated Swiss remedy, purchased by the King of France, was a sharp purgative, and proved to be twelve grains of calomel and twelve grains of scammony, followed shortly after by ℥ss. to ℥j. of the sulphate of magnesia. It is questionable, however, whether calomel is an essential part of the treatment, for Rossenstein administered it many times, so as to produce salivation, without expelling a single worm; and Brera adds that, in the mines of Lydria, and in the laboratory of Chemnitz, in Hungary, and at Freyberg, in Saxony, where they use much mercury in purifying gold and silver, he has seen worms endemic among the workmen.

In the London hospitals the purgative treatment is seldom adopted, it being more usual to exhibit the oleum terebinthinæ neat. Half an ounce of this medicine makes the patient slightly tipsy, and produces three or four motions; and in these the worm is usually found, the animal having, it is supposed, a great antipathy to this substance, lets go its hold and actively attempts to escape. This medicine may be repeated twice a-week. Three-fourths of the inhabitants of Cairo are said to be infested with tænia, and their remedy is twenty to thirty drops of petroleum; a remedy not greatly dissimilar. The Grenadine bark has acquired much reputation in this disease in the West Indies, but it has not supported the hopes that have been entertained of it, at least in this country.

The situation of these worms render enemeta of little value, but cold quickly destroys them. They seem to rejoice in heat, for Coulet boiled a tænia in veal broth for twelve hours, and it was as lively at the conclusion of the experiment as at the commencement.

The diet in these cases should be nourishing, and intermixed with a considerable portion of animal food.

*Scurvy—Scorbutus.*—The muriate of soda, when largely eaten in combination with animal matters, acts as a poison, and, like most other poisons, produces in the first instance an extreme depression of the vital powers, which is followed by a general tendency to hæmorrhage from the gums, also into the sub-cutaneous cellular tissue, and from the mucous membrane of the nose, intestines, and of the lungs.

Scurvy is mentioned by Pliny as having occurred in the Roman army commanded by Germanicus. It prevailed also, to a frightful extent, in the army of St. Louis, when he was made prisoner in Egypt. But it was not till navigation was improved, and long voyages undertaken, that this disease became well known from its general prevalence and formidable character. Vasco de Gama, in his first voyage to the East Indies by the Cape of Good Hope, in 1497, lost 100 men out of 160 by this affection. James Cartier, in his second voyage to Newfoundland, in 1535, speaks of suffering still more severely, as, of 110 people, there were not ten whole; and it is plain he considered it to be contagious. The scurvy continued to prevail, with little abatement, till 1794, when an improved state of society, and a better diet introduced into the navy, have so reduced it that, in the year 1839, only 101 cases are reported to have died of scurvy in England and Wales.

*Remote Cause.*—The remote cause of scurvy is, unquestionably, the too abundant use of salt provisions; and the whole history of the disease is a proof of this fact. In the middle ages, as they are termed, scurvy prevailed epidemically among the inhabitants of the low countries of Holland, Friesland, Brabant, Pomerania, Lower Saxony, and, indeed, in all countries from the 50° to the 60° of north latitude. This was caused by the absolute want of winter food for the cattle, so that it was necessary to kill them on the setting in of the frost, and either to salt or dry the flesh. Hence the large stores of salt provisions found in the larder of the elder Spencer, in the days of Edward II., even so late in the spring as the 3rd of May, or 600 bacons, 80 carcases of beef, and 600 muttons. In all these countries, however, in proportion as agriculture has advanced, and a succession of green crops enabled the farmer to kill his best and fattest meats in winter, and in proportion, also, as vegetables have been introduced at our tables, together with a liberal use of wine, so has this disease disappeared. The former universal prevalence of scurvy, also, in the navy, and its almost entire disappearance in the present day, necessarily has reference to a particular cause, or the too abundant use of salt provisions. "In 1797 the victualling of the navy was changed, greatly improved, and strictly regulated; and, immediately consequent to the change, the health of the seamen improved strikingly. Scurvy, typhoid fever, dysentery, and putrid ulcer, which, up to the period of the change, produced great havoc, became comparatively rare in occurrence and light in impression." "Since 1797 the improvements have been, giving cocoa instead of gruel (burgo) for breakfast, issuing salt meats at a much earlier period after being cured, the supply of better articles and in greater abundance by one-third, and also the substitution of tea in the afternoon instead of spirits; and, with every improvement in these respects, there has been, as a general result, a further improvement in health, till the four forms of disease, at no distant date so destructive, are scarcely known except by name."

It seems probable, however, that there may be other causes, which, combined with peculiarity of idiosyncrasy, are capable of producing the disease, for a few cases (and the number is but small) apply to the hospitals with what has been termed the land scurvy; the patients, according to their own account, not having eaten either salted, cured, or smoked meats; a form of disease which appears to have broken out among our troops a few months ago, at the Cape of Good Hope, while defending the back country from the Caffres.

*Predisposing Causes.*—Scurvy is seldom seen except in male adults, between the ages of fifteen and forty, that class of persons being most exposed to the remote cause. It seldom, however, occurs in women, for they are rarely placed under the necessity of living on salted provisions; but when they habitually indulge in what is usually termed "a relish," they often suffer from it. The other predisposing circumstances are insufficient nutriment, severe disease, anxiety, and wet or damp. The effects of anxiety of mind, in producing the disease, greatly struck Dr. Lind. "We often observe," he says, "our channel cruisers overrun with scurvy; while their consorts, fitted out at the same port, and consequently with the same state of provisions, and striking out into the main ocean, upon a voyage to India, or

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upon a much longer cruise off the Canaries, or Cadiz, keep free from it." He also remarks that the warrant officers, who lie in warm dry cabins, and go better clothed, are seldom attacked with it; while the common sailors, exposed to wet, and whose berths were seldom dry, were almost destroyed by it. Spirits are said also greatly to predispose to this disease.

*Pathology*.—The days of scurvy were not those of posthumous examinations, and our knowledge of the pathology of this disease is derived principally from Poupart and Lind. In those cases in which flux or dysentery is absent, the intestines, however copious the hæmorrhage from them, have been found perfectly sound. The principal effects of the disease were observed in all cases in the cellular tissue of the extremities. The quantity of congealed blood effused in that part, even where no stain or mark could be perceived on the skin, was quite astonishing. "It often lies," says Lind, "in large concrete masses on the periosteum, while the bellies of the muscles of the legs and thighs seemed quite stuffed with it, often an inch in thickness." He also often found water effused into the cavities of the chest and abdomen, and no less frequently blood,—the quantity of blood effused in all parts sometimes amounting, in his opinion, to no less than a fourth part of that contained in the whole body. Poupart gives some further particulars, and says that, on moving the limbs of some scorbutic patients, a noise is heard; and that, on examining the joints, the epiphyses had entirely separated from the bones; and in other cases, that the cartilages of the sternum had separated from their bones. He says, also, if we squeezed the ribs which had begun to be thus separated from their cartilages, "there came out abundance of corrupted matter, so that nothing was left of the rib but its bony plates." The mesenteric glands, also, were usually enlarged, the spleen often three times bigger than natural, and fell to pieces as if composed of coagulated blood. In two cases lately examined at St. Thomas's Hospital, patches of ecchymoses were found under the pericardium covering the heart, and also under the arachnoid membrane covering the brain.

*Symptoms*.—Scurvy is divided into two kinds, or into sea scurvy, *scorbutus maritimus*; and land scurvy, or *purpura scorbutica*.

The first symptoms are, a yellowness of countenance, great depression of the physical powers, followed by the gums swelling, becoming *spongy*, and readily bleeding. A small pulicose eruption (like flea-bites), of a purple hue, is next seen on the lower extremities; and about the same time the muscles of the leg or thigh become hard and painful, and in a day or two the skin over the pained part becomes first yellow and then purple. This discolouration forms patches sometimes as big as the palm of the hand, and then again extending over half the leg and thigh. The tongue is now white, the breath fœtid, and the stools generally pale. As the disease advances, all these symptoms are aggravated. The loss of physical power increases, the purple spots have a tendency to ulcerate, and the ulcers are distinguished from all others by their putrid fungoid appearance and great tendency to bleed, old sores open, and the callus of broken bones has even been dissolved and their ends separated. Profuse hæmorrhages also frequently take place from the mouth, nose, lungs, or bowels. The teeth also become loose, so that they either fall out or may be taken out by the finger and thumb. The pulse hurries on to 120 or 140, and at length the patient sinks from diarrhœa or dropsy, and with effusion so sudden that he perhaps has walked to be shaved, and then died in a quarter of an hour afterwards. The duration of the disease is generally many weeks, and sometimes, under the most favourable circumstances, many months, the patient recovering his strength extremely slowly.

The land scurvy is a much milder disease, the patient preserving his general good health. The legs, however, swell, and are painful and covered with petechiæ or patches of ecchymosis. The duration of this form of the disease is also often long and tedious, lasting many weeks or months.

*Diagnosis*.—The scurvy is to be distinguished from flea-bites, bruises, petechial fever, and from purpura syphilitica.

*Prognosis*.—In the present day, when the patient can command medical care and proper diet, the scorbutus maritimus, though tedious, is seldom fatal. When these, however, have been wanting, the mortality has been terrible. Lord Anson, it should be remembered, in his voyage round the world, lost above 200 men, and at last could not muster more than six foremast men in a watch fit for duty. At the commencement of the late war, on the fleet returning from sea, it often happened that so many men were landed ill of scurvy, that even Haslar Hospital, large as it is, could not contain them, and many were lodged in the chapel, others in tents, while others died in the boats before reaching the shore.

*Treatment*.—The early history of navigation, as it records the greatest ravages of scurvy, so does it also record the best antidote to the disease. Lord Anson's people, on reaching the island of Tinian, were recovered principally by eating oranges, of which that noble, brave, and experienced commander was so convinced, that, before he left the island, he ordered one man from each mess to lay in a stock for future security. Sir Charles Wager's people, also, were terribly afflicted with scurvy in the Baltic. Sailing, however, in the Mediterranean, and having heard how effectual oranges and lemons were in the cure of this disease, he took on board, at Leghorn, a large quantity of them, ordered a chest each day to be brought on deck, and allowed the men, besides eating what they chose, to mix the juice with their beer, and also to pelt each other with the rind, so that the deck was strewed with the fragrant liquor. By these means he brought his men home in good health.

In the year 1747, Dr. Lind made some comparative trials between this and some other modes of treatment, as vinegar, vitriol, and tamarinds, on board the "Salisbury," at sea. As a general conclusion from his experiments, he affirms that orange and lemon juice, or more properly, the citric acid obtained from all the species of the botanical genus *citrus*, or the natural order of fruits called *hesperidæ*, are greatly more efficient than any other remedy in the cure of scurvy.

Notwithstanding this strong opinion of Dr. Lind, the navy continued to suffer severely from the scurvy for half a century, till the Admiralty gave a general order for the supply of lemon-juice. This salutary measure was accomplished by a representation from the Medical Board of the navy, in the year 1795, when Lord Spencer was First Lord of the Admiralty, after a trial made on board the "Suffolk," of seventy-four guns. This ship sailed from England on the 2nd of April, 1794, supplied with a quantity of lemon-juice sufficient

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to serve out two-thirds of a liquid ounce daily to every man on board, and this was mixed with their grog along with two ounces of sugar. She arrived at the Madras roads on the 11th September, after a passage of twenty-three weeks and one day, without having had any communication with the land, without losing a man, and having only fifteen on the sick list. Scurvy appeared in a few of the men during the voyage, but disappeared on an increased dose of lemon-juice being administered. "Let this fact," says Sir Gilbert Blane, "be contrasted with the state of the channel fleet, in 1780, when Admiral Geary's fleet returned into port, after a ten weeks' cruise in the Bay of Biscay, with 2,400 men ill of scurvy; and let the state of this fleet be contrasted with that of the channel fleet in 1800, which, by being duly supplied with lemon-juice, kept the sea four months without fresh provisions, and without being affected with scurvy."

It is, perhaps, hardly fair to attribute the improved health of the navy entirely to the introduction of a daily allowance of lemon-juice, considering that the quantity was greatly increased and the quality of the diet greatly improved contemporaneously with this addition. It is gratifying, however, to see how largely these combined measures have improved the health of the navy and rewarded the cares of those who superintend it; for, during the nine years preceding these changes, the sick seamen sent to the hospitals were one in 3·9, while in the nine succeeding years the proportion was only one in 8·4; so that not only has scurvy almost disappeared from ships of war and naval hospitals, but the efficiency of the navy has actually been increased threefold. The negantia in sea scurvy are bleeding and mercury. When the patient has been bled it has been found that the red globules and fibrine are decreased and the albumen increased; the red globules being 119, the fibrine 1·6, and the serum 86 (Andral).

The citric acid, however, although an antidote to sea scurvy, is by no means so with the *land scurvy*. In this latter disease, contrary to the former, the patient is generally benefited by the application of leeches to the legs, and by moderate purging. The cathartic is perhaps unimportant, but the sulphate of magnesia ℥j. ex infusi rosæ ℥fs. ter die, is often efficient.

The diet in every form of scurvy ought, as far as possible, to be fresh meat and vegetables; and, where it can be procured, a daily allowance of wine or porter. It is said that two vessels went on shore on the inhospitable coast of Greenland; one saved salt provisions enough to carry them through the winter; while the other lost everything, and the crew were obliged to live on what accident threw in their way. On the return of the whalers the following spring, the crew of the former had all died of scurvy, while the crew of the latter were still living.

### Of the Effects of Alcohol.

"Dulce periculum est:
O Lenæe sequi Deum
Cingentem viridi tempora pampino."

The number of persons that die from diseases produced by alcohol is calculated to be at least one-fourth of the whole adult male population, together with a considerable proportion of adult females of the lower classes. This estimate will appear less extraordinary, when it is stated that, besides producing intoxication, this fluid, like other poisons, is absorbed and mingles with the blood, and may be obtained from the blood by distillation. Its presence in the circulating system is not harmless, for it causes many organic as well as functional diseases. The organic diseases are altered structure of the arteries, also of the liver, of the stomach, and of the kidneys. The effects of alcohol on the arteries, and especially of the aorta, as constantly seen in the drunkard, are thickening and thinning, ulceration and ossification of the coats of those vessels, and in this manner their elasticity is destroyed, and they are rendered pouchy and aneurismal. The diseased state of the arteries re-acting on the heart produces enlargement and hypertrophy of that organ, till the whole balance of the circulation is destroyed, and the patient rendered liable to apoplexy, asthma, and dropsy. Besides the specific effects of alcohol on the arteries, it likewise affects the liver, which usually becomes enlarged, hardened, and granular. The stomach, also, is generally indurated, thickened, and contracted, while the kidneys are liable to every species of disorganization.

Such are the structural lesions alcohol produces; but in addition to these, many functional diseases result which often end in the death of the party: thus it is estimated that one-third of all the cases of insanity arise from habits of inebriety. In some persons, indeed, every fit of intoxication is a fit of insanity, and most of the murders, acts of incendiarism, of insubordination to military discipline, or of brutal violence, are committed during the paroxysm. The diseases of function it is now intended to note, and which are the immediate result of alcohol, are *delirium tremens*, or the consequences of several days continued intoxication, and *asphyxia temulenta*, or the fatal consequences of drinking to great excess at one bout.

*Delirium Tremens* is a general and excessive disturbance of the functions of the cerebral and nervous systems, causing sleeplessness, hallucinations, great trembling of the hands and upper extremities, with or without fever, and is a disease which runs a short and often fatal course.

This disease was little known till Dr. Sutton called the attention of the profession to it in the beginning of the present century, as an affection he often met with among the smuggling sea-faring population on the coast of Kent. Since that time it has become well known, and 206 cases died from it in 1839 in England and Wales, while the returns from the East and West Indies show that it is frequent in our colonies.

*Remote Cause.*—The party affected with delirium tremens is not the wine and beer drinker, but the drinker of spirits to such excess as to be in a continued state of intoxication for several days. It is consequently most usual in London about holiday time.

*Predisposing Causes.*—Both sexes are liable to this affection, and of the 206 who died in this country of this disease in 1839, 184 were men, and 22 women, and we regret to add that this proportion of females is greater than in many continental towns.

*Pathology.*—The pathological phenomena which have been discovered on the inspection of those who have died of delirium tremens have been a few more *puncta cruenta* than usual of the brain, and also some thickening or congestion of the membranes, with effusion into the cavities of the arachnoid and of the ventricles. In some very few instances the fluid in the ventricles has smelt of the spirit that has been drank, and so also has the blood drawn from the arm.

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*Symptoms.*—The symptoms of delirium tremens generally appear from the second to the eighth or ninth day after a protracted debauch, and are by some pathologists divided into three stages. The first stage, according to Dr. Blake, is marked by a peculiar slowness of the pulse, by coldness and clamminess of the hands and feet, by general debility, by nausea and vomiting in the morning, and by frightful dreams at night. The tongue, also, is tremulous and furred, the hands shake, the patient is greatly depressed in spirits, sighs frequently, is anxious about his affairs, and is either restless or watchful. These symptoms last from 24 to 48 hours.

The second stage commences by a hurried and anxious manner, by great excitability of temper, by a small accelerated pulse; some heat, perhaps, of the surface of the trunk, but accompanied with the same coldness and clamminess of the extremities. The tongue is sometimes clean, but often brown and dry, and the patient delirious, suffering from various mental illusions and alienations. In general, the delirium is melancholy, and has reference to his usual occupation and habits, or to some difficulty in his domestic affairs. He sometimes sees flames, or hears voices talking to him; and one man, as soon as he shut his eyes, saw people passing under the bed-clothes. Restless and sleepless, he moves his trembling hands horizontally over the bed-clothes, as if seeking for something. In general, he is harmless, and easily controlled; but in some instances the party is violent, mischievous, and requires to be strapped down in bed. This stage generally lasts from three or four days to a week, when the third stage commences by the patient falling into a sound sleep, and gradually recovering, or else a fatal collapse comes on, which finally and shortly closes the scene.

*Diagnosis.*—Delirium tremens is to be distinguished from typhus fever and from paralysis agitans only by the previous history.

*Prognosis.*—It is hardly determined what is the proportion of recoveries to deaths, but unquestionably three persons out of four do well.

*Treatment.*—The rule of treatment in this disease is by opiates and stimuli. In mild cases, when the tongue is *white*, many recover under mist. camphoræ ℥ xj. sp. æth. nitr. ʒ j. e. syr. papaveris ʒ j. vel tinct. hyoscyami ♏ xx. 4<sup>tis</sup>. In severe cases, when the tongue is either clean or brown, one or two grains of morphine or of opium, given every two hours till sleep is procured, has entirely cured the patient. It is, generally, however, necessary to support the patient for some days after by camphor mixture, and by a small portion of wine and water, or brandy and water. By physicians who have attempted the heroic treatment, as much as ℥fs. of tinct. opii, or 20 grains of opium, have been given at a dose in these cases, but this appears to be a great excess.

The dietetic treatment should be slops and light farinaceous food.

*Asphyxia Temulenta.*—Delirium tremens is generally the result of some days' hard drinking; but some persons, either through bravado, for a wager, or from ignorance, have been tempted to drink one or two pints of spirits at one draught. In these instances the effects of the poison are widely different from the delirium tremens caused by long-protracted debauch, for instead of excitement, delirium, and tremor, the brain becomes oppressed, and the patient falls down, and lies without any power of voluntary motion, without consciousness, and almost without sensation, and in this state he frequently and shortly dies.

*Pathology.*—On examining the bodies of those who have died during intoxication, the appearances observed are those of asphyxia rather than of apoplexy. The appearances, indeed, are rather external than internal; the countenance bearing marks of anxiety, and sometimes of convulsions; the eyes being prominent, and the pupil dilated; the face swollen and livid; the lip blue; the cellular tissue vascular, and its blood dark and fluid; all the abdominal and pectoral viscera likewise are loaded with dark fluid blood, as also the brain and its membranes. The veins and larger arteries, as also both sides of the heart, are loaded in like manner with black blood. Some effusion is likewise observed in the cavity of the membranes of the brain, and also into the ventricles, but it is small in quantity, and perhaps is merely a consequence of the agony. These appearances seem to denote a specific action of the alcohol on the nervous system, producing instantaneous palsy of the eighth pair, as well as of the functions of the brain generally.

*Symptoms.*—In the great majority of cases, shortly after taking the spirits, the party* becomes drowsy, if sitting, and appears to fall into a sound sleep, but, if standing, he falls down; while if the attempt be made, he cannot be roused to consciousness, or only partially so, and then immediately relapses into the same comatose state. His limbs remain motionless, or, if lifted up, fall powerless; his face is pale or flushed; his eye injected, sometimes squinting, and the pupil either contracted or dilated. The temperature of his head is above that of the trunk, which is either natural, or below the usual standard. The pulse is feeble, slow, varying from 70 to 108, and often entirely wanting. The breathing slow, and if the hand be placed over the chest, no expansion is felt, the respiration being altogether abdominal. In four cases, says Dr. Ogden, the patients manifested no sense of feeling, either when the skin was pricked, or the nostril tickled with a feather. The patient generally dies convulsed.

*Diagnosis.*—The disease is distinguished from apoplexy, or other disease, by the breath being tainted with spirits, and also by the history of the case.

*Prognosis.*—A very small number of cases recover from this extreme state of intoxication, but when the pulse is wanting at the wrist, the patient cold, and the respiration laborious after the alcohol is removed from the stomach, the case is hopeless.

*Treatment.*—The practice is, in the first instance to empty the stomach, either by an emetic, or by the stomach-pump, to apply external warmth, and to exhibit diffusible stimuli, as ammonia; or, according to Orfila, hot coffee; and, according to others, vinegar. The practice of blood-letting, when called to a patient suffering from an overdose of ardent spirits, though a common is yet generally esteemed a most pernicious error.

### Colica Pictonum.

Lead has been introduced into the system, both formerly and in the present day, in a great variety of ways; formerly, in France, from putting a lump of litharge or lead into *vin gâtée*, in order to render it saleable, a crime which has been made capital in most countries of Europe; and from this having been prac-

* Ogden, *Medical and Surgical Journal*, vol. xl.

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tised to a great extent in Poitou, the disease has been termed *Colica Pictonum*. In the cider counties of Great Britain this disease formerly existed to a great extent, and has been termed Devonshire colic, or *Colica Damnoniensis*. The impregnation of cider with lead in this country was generally the effect of accident, and arose from the troughs in which the apples were crushed having the different pieces of stone, of which they are composed, cramped together with iron, and fixed by melted lead. In some districts it was the practice to line the entire press with lead, or else to tip them with that metal. It was a custom, also, almost universal to make the upper part of the boiling vessel of lead, while some growers, in managing weak ciders, put a leaden weight in the cask to sweeten the liquor. From these and perhaps other causes, Sir George Baker found the cider he examined to contain 4½ grains of lead in 18 bottles, or a quarter of a grain in each bottle. In the West Indies, these diseases appear to have been produced by using leaden worms to the stills, by which the rum became impregnated with this metal. There are many other minor sources of poisoning by lead, as keeping pickles or preserves in glazed earthen vessels, and colouring sugar-plums with lead; while many children formerly suffered from eating wafers coloured with red lead—*cognitio causæ tollit morbum*; and the still and other machinery used in the distillation of fermented liquors being now constructed of metals so combined as not to be acted upon by acid fruits or sugar, these diseases are no longer epidemic, but are confined principally to labourers in the lead manufactories and to painters.

*Predisposing Causes.*—All ages, both sexes, and all classes are liable to the poisonous action of this metal, but the workers in lead have been at all times the greatest sufferers. Women in this country often suffer from colic, but it is rare to find them paralytic; men suffer both from the colic and the palsy.

*Pathology.*—The theory of this disease is, that the lead is absorbed and mingles with the blood, and produces that functional disease of the fibrous structure of the alimentary canal, termed colic; also of the muscles of the extremities, producing palsy, and likewise ulceration of the gums and alveolar processes, accompanied by a peculiar blue line, and which has only lately been pointed out by Dr. Burton, of St. Thomas's Hospital.

The fact of the lead being absorbed and mingled with the blood is demonstrated by the circumstance that lead has been obtained from the coats of the stomach of a dog poisoned by lead, even as late as a month after poisoning. Again MM. Duvergie and Guibourt have detected lead in the brain of the human subject, and Dr. Budd has detected it not only in the human brain, but also in the muscles. Many pathologists, also, are inclined to believe that the blue line observed in the gums of persons poisoned by lead is owing to the presence of lead in some peculiar state of combination. It follows, from what has been stated, that there are various tissues of the body for which lead has an affinity, and that it enters into chemical combination with them.

*Colica Pictonum* rarely causes death in the present day, but the facts we do possess show it to be a disease of function and not of structure. Dehaen opened many persons that fell from this disease, and says he found in all a constriction of the colon, and in a certain number a similar affection of the cæcum. Merat opened, also, seven cases, and all that he observed was a constriction of the colon. Dubois de Rochfort says that he found in two cases intussusception of the intestines; but Andral, however, has examined five cases, Louis one case, and Martin another, without finding any morbid appearance.

Mr. Hunter had an opportunity of examining the state of the muscles of the palsied hand and arm of a painter who died of a broken thigh in St. George's Hospital, and found them all of a cream colour. Dr. Williams, however, of St. Thomas's Hospital, had an opportunity of examining the palsied muscles of the arm of a painter, but they had an entirely natural appearance, though wasted. Dr. Budd had also an opportunity of examining a similar case at King's College Hospital, yet, although the extensor muscles of the wrist and muscular fibres of the colon were examined under a microscope, nothing unusual was discovered, except that the extensor muscles, like palsied muscles in general, were more easily separable into their component parts than in health.

*Symptoms.*—The quantity of lead necessary to produce its specific results, or the time it takes to accumulate in the system when introduced, is not determined, and both the dose and the time, perhaps, varies greatly in different individuals. Sometimes all its most pernicious effects are produced by one dose taken by the mouth; and then again, if introduced by the skin, months and even years may elapse before the system is laid under its influence. As a general rule, however, a much smaller dose will produce colic than is necessary to produce palsy.

When the dose is of such intensity as to produce colica pictonum; the symptoms do not differ, except in being of greater intensity from those which have been stated as marking ordinary colic. There is the same dragging and twisting pain, and the same relief by pressure; the same absence of fever; the same unhurried pulse; the same constipation, only more obstinate, and in the worst cases the same vomiting. Andral, however, who has treated upwards of 500 cases at La Charité in the course of eight years, says it is not strictly true that the pain in lead colic is always diminished on pressure, for in the greater number of cases pressure neither augments nor diminishes the pain, while in some cases the sufferings of the patient are increased by it. He also says it is as common to find the abdomen distended with gas as to find it drawn in, and the rectus strongly contracted. The symptoms peculiar to this form of colic are, occasionally an attack of epilepsy, and an ulcerated state of the mouth, accompanied by a blue line on the dental edge of the gum,—a discovery which the profession owe to the patient and careful observation of Dr. Burton.

The duration of colica pictonum is very various: in one instance lately, in St. Thomas's Hospital, fifteen days had elapsed without a stool. More commonly, however, only three or four days elapse before a stool is procured, and when the case is early submitted to medical treatment seldom more than a few hours. As soon as the bowels act the great severity of the disease is mitigated; every symptom is gradually relieved, and the disease generally terminates within a week.

When palsy is the result of the absorption of lead, a painful state of the arms often precedes it, which at length terminates in palsy. The palsy is in general limited to the upper extremities, when it may be partial or confined to the hands, causing the "wrist drop," or

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to one finger. More commonly, however, it affects the whole arm, and sometimes so completely that the patient can execute no movement with it, and when lifted up it falls like an inert mass. Again, sometimes the extensor muscles of the limb are alone affected, and in this case the hand is often strongly closed by the powerful and unresisted action of the flexors. In general both arms are palsied, but not equally so, one being something more affected than the other. Supposing both sets of muscles to be equally palsied, the patient usually recovers the use of the flexors before that of the extensors, so that he can carry a pail of water before he can shave himself. This restoration of the lost power is usually accompanied by pain. In a very few remarkable instances the lower extremities are equally affected, an example of which is now in St. Thomas's Hospital, the extensor muscles being palsied, and the patient walking as if slip-shod, or like a bird. The duration of the palsy under any treatment is always long, and often lasts many months, and in some cases, many years. Both colic and palsy may occur an indefinite number of times. When epilepsy, which is a rare symptom, is produced, the fit does not differ from epilepsy of the ordinary character.

*Diagnosis.*—This colic can only be distinguished from ordinary colic by the history of the case, and by the blue line on the dental edge of the gums.

The palsy is distinguished from cerebral paraplegia by the history of the case, by the integrity of the intellect, and by the blue line on the gum.

*Prognosis.*—The termination of lead colic, except where the dose has been in such excess as to produce death in a few hours, is always favourable.

The palsy does not appear greatly to affect the health of the patient, but in some cases it has hitherto not been cured or relieved. In general, however, the patient does recover, although, perhaps, not completely.

*Treatment.*—The treatment of colica pictonum is extremely simple. The objects to be obtained are to procure stools and allay pain. For this purpose five grains of calomel, fifteen grains of jalap, and one grain of opium should be administered as soon as the patient is seen, and at the end of two hours the mistura camphoræ ℥ij. e. magnesiæ sulphatis ʒj. c. tinct. hyoscyami ♏xx. should be given every two or every four hours till the bowels are freely evacuated, when relief more or less complete is obtained. The mixture should be continued at proper intervals for three, four, or five days, when the patient, though greatly weakened, has in general recovered.

In a few cases, however, the pain continues, and with considerable severity, after the bowels have been freely evacuated. The practice in these instances is to apply a blister to the epigastrium and to keep it open for a few hours; and this additional application completes the cure. Calomel to salivation has not appeared to influence the disease beneficially, and bleeding is decidedly bad practice.

In addition to the purgative treatment, the patient is much relieved if placed in a warm bath, and so simple is the treatment of this colic, that Dr. Wilson, of the Middlesex Hospital, affirms, if the patient be now directed to inject repeated enemata of the water of the bath, that stools will be readily obtained. In the absence of the warm bath a large linseed or mustard poultice should be applied over the abdomen.

With respect to the cure of lead palsy, an endless variety of treatment, both local and general, has been tried, but with so little positive result, that when the patient has recovered it has been doubtful whether it has been owing to the great length of time that has elapsed, or to the medicines he has been taking. There is only one medicine that appears an exception to this rule, and that is the ergot of rye (secale cornutum), and there is some hope that this is a specific for the disease in doses of gr. x. ter die. As far as it has been tried, it produces a considerable increase in the power of the flexor muscles of the arm in about a fortnight, and the improvement gradually extends to the flexors till at the end of about three months the patient has recovered. Supposing this medicine to prove a specific, in what manner does it act? Is it by imparting increased power to the nerves, or by combining with the lead incorporated in the muscular tissues, and rendering it more readily absorbable? The experiments of Orfila render it probable that lead is removed from the body by the kidneys, for on carbonizing a portion of urine of a young girl who had taken about an ounce of acetate of lead with an intention of committing suicide, and treating the residue with nitric acid, and submitting it to the usual tests, he obtained a sensible portion of lead, showing that the kidneys are one of the means by which this metal is removed from the body.

### Fish Poisoning.

The subject of fish poisoning is one of the most singular in the whole range of dietetics. Many persons have an idiosyncrasy so peculiar that even cod or salmon will produce an eruption or other temporary disease. It is well ascertained that the oyster, and still more the muscle, at times acquires properties which render it poisonous or hurtful. Vancouver had four sailors taken ill, after eating muscles, of whom one died in five hours and a half. Two fatal cases also from the same cause occurred in the practice of Dr. Combe.

It has been thought that the muscle might acquire its poisonous qualities by feeding on a bed of copper, but Dr. Christison analyzed some muscles taken from the stomach of Dr. Combe's patient without finding a trace of copper; and subsequently it was ascertained that, so far from feeding on copper, the muscles in question had been taken from some Memel fir logs which had lain at the mouth of the harbour for fifteen years. The particular poison, therefore, must be an animal poison acting on a peculiar temperament.

The symptoms which poisoned muscles give rise to are great pains in the stomach, some fever, and a very general erythematous eruption; some also are said to suffer from coryza, and others from peritonitis, and these symptoms last for a week or ten days.

The treatment of poisoning from muscles is generally an emetic, and often bleeding and other rough treatment. It is singular, however, that the most efficient remedy is to drink copiously of milk. In what manner milk acts is uncertain; some imagine that the poison is mechanically entangled in the coagulum, and thus more easily brought under the action of digestion. The more probable mode, however, is, that the poison becomes chemically combined with the caseous portion in the same manner as corrosive sublimate unites with albumen, and is thus in a great measure rendered harmless. Whatever be the *modus operandi* of milk, it is certain that in a few hours the patient is relieved, and, by attention to the bowels, speedily recovers.



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Besides fish poisoning, three common articles of food have often produced death in Germany, as sausages made a long time, and of meat that has been boiled before being salted and hung up; also old cheese and rusty bacon. Dr. Kerner has determined the poison of the sausages to be an acid formed in consequence of a modified process of putrefaction. Dr. Daun, however, affirms it to be the empyreumatic oil. Old cheese is supposed to be poisonous from the conversion of the curd or caseum into the caseate of ammonia, the caseic acid being said to be so poisonous that a drachm and a half procured from cheese killed a cat in eight minutes. The poison of rusty bacon is said to be sebacic acid and an acrid oil. Meats thus prepared are often sensibly obnoxious to delicate stomachs at a much earlier period of decomposition than is here pointed out. Thus many persons are unable to eat French pâtés, however delicately flavoured. The mode of treating the diseases caused by these poisons is not determined.

### Of the Neuroses of the Liver.

The liver is the largest organ of the body, and has been found to weigh, in the healthy adult, from two to five pounds. It receives nerves from the eighth pair, thus putting it under the influence of the passions. Its office is to secrete bile, a fluid which all physiologists have considered of the first importance in the animal economy. What, however, is the peculiar purpose of bile is not determined; some physiologists consider it as subservient to digestion, and others that it is an excrementitious matter separated from the blood and removed by the alimentary canal, while others affirm that it acts as a natural tonic to the intestines, and regulates, perhaps, both the absorption of the chyle, and also the peristaltic motion. The neuroses of this organ are jaundice and gall-stones.

*Icterus, Jaundice*, the *Yellows*, is the absorption of bile and its circulation with the blood, whence many of the different tissues and fluids of the body become dyed yellow, but more especially the conjunctiva and the cutaneous tissue, for which the bile appears to have a great affinity.

This disease was known to Hippocrates and to all succeeding writers. The term *icterus* is said to be derived from the complexion of the jaundiced person resembling the golden thrush, and by looking on which, like the Israelites of old on the brazen serpent, it was supposed the patient would be cured. Another odd term is *morbus arquatus*, from bad cases of jaundice presenting almost as many and as varied colours as the rainbow. 800 cases of this disease died in England and Wales in 1839.

*Remote Cause.*—The bile, although constantly secreted, is only poured into the duodenum at the time when digestion is going on, being in the interval received into the gall-bladder. Any defect, therefore, of that sympathy which exists in health between the duodenum, the gall-bladder, and hepatic ducts may cause the bile to be retained and the patient to be jaundiced. Among the causes of jaundice, therefore, may be enumerated every functional or structural disease of the stomach and duodenum, and also of the liver itself; and among the causes of the diseases of the latter organ, the paludal poison and excessive indulgence in ardent spirits may be mentioned as the most prominent. Mechanical causes also occasionally produce jaundice, as an enlargement of the head of the pancreas, or an aneurismal or other tumor pressing on the *ductus communis*. Dr. Young gives a singular case of jaundice in which a hydatid had got entangled in the *ductus communis*, and completely obstructed the passage. In this case the liver adhered to the diaphragm, and the diaphragm to the lungs, and an abscess formed, so that all these parts communicated with the bronchi, and pus and bile passed into the lungs, and was thus obsolutely spat up by the mouth. Pregnant women are also often jaundiced, and as is supposed from pressure of the uterus.

As the brain is put in communication with the liver by means of the eighth pair, the passions often produce jaundice. A woman was upset in a boat on the Thames, and the next day she was jaundiced. An untoward accident threw a lady into a violent passion, when in a few hours she was jaundiced. A medical gentleman is mentioned by Mr. Cooke who became jaundiced every time he had a difficult case under his care, and a young man is stated by Morgagni to have become jaundiced from having a gun pointed at his breast.

*Predisposing Causes.*—New-born infants are liable to jaundice, and it may occur at any subsequent age. It is most common in the heyday of the passions, or between 20 and 40. Women are supposed to be more liable to this affection than men. In some few instances jaundice appears to run in families, for Mr. Pearson speaks of a family of 17 children, of whom 10 had died shortly after birth of jaundice, and another about six years old.

*Pathology.*—Jaundice, though often a result of every organic disease of the liver or duodenum, yet often occurs when those organs are perfectly healthy, and is consequently in many cases merely a disease of function. On posthumous examination, besides the yellowness of the cutis, the serum of the blood is generally found loaded with bile and perfectly yellow; and in one case of *icterus arquatus*, singular to say, though the patient was yellow, yet the serum of the blood taken by cupping was green, and from which, nevertheless, the albumen, on the addition of nitric acid, was thrown down yellow. If the disease is at all chronic the fat is also yellow, as well as the bones and cartilages. All the serous fluids are likewise yellow, and even the milk is said to be expressed yellow from the breast of a suckling female.

The theories that have been formed to account for jaundice, are, that the bile exists formed in the blood, and is merely removed by the liver, and consequently jaundice is a consequence of the non-separation of the bile. A more common opinion is, that bile is a secretion and not a separation, and consequently that in jaundice the bile is first secreted and then absorbed both by the veins and lymphatics, while Portal has proved that it may be absorbed in a third manner, or by the lacteals. Every attempt to prove by experiment whether bile is secreted by the arteries or veins has been either unsatisfactory or has failed; but reasoning from the structure of the liver, and that the portal vein ramifies after the manner of an artery through this organ, most physiologists have concluded that this latter vessel is the great secreting system of the bile.

*Symptoms.*—Jaundice, from the different intensities of the colour of the skin, has been divided into the yellow, the green, and the black jaundice.

Jaundice, arising from functional disease, may be sudden in its attack, or it may be preceded for a few

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days by great depression of spirits, lassitude, and somnolescence. It may also be preceded or accompanied by some slight pain in the region of the liver, but more commonly pain is not present.

The first symptom of jaundice is a yellowness of the white of the eyes, then of the roots of the nails, or of that part termed "the half-moon;" the yellowness next appears over the face and neck, and ultimately over the trunk and upper and lower extremities. As soon as the eyes are affected the urine becomes of a deep red colour, and stains linen steeped in it yellow, and if nitric acid be added it is changed to a deep green. The bile, however, is not always in the same state of combination in the urine, or else not of the same quality; for, in some instances, where the colour of the patient is most marked, and the urine of its deepest hue, the addition of nitric acid effects no change. At the same time the urine is thus discoloured, the stools, often abundant in quantity, are copious and white. The pulse is slow, and the patient complains of a bitter taste in the mouth, has much thirst, an absolute inaptitude to all exertion, and suffers from a lowness of spirits, amounting to hypochondriasis. In general the bowels are irritable and easily acted upon; but, in a few cases, they are constipated. If the patient recovers, the first symptom is the appearance of bile in the stools, and after this the yellowness fades away in the inverse order of the attack, or first from the legs, trunk, chest, face, and, lastly, from the eyes; and in proportion as the yellowness disappears from the body the bile in the urine decreases, till at last it disappears altogether. On the contrary, if the patient falls, his death is generally preceded by delirium or dropsy.

The duration of this affection is very various. In some cases it terminates in about ten days, but more generally it lasts from three to six weeks, and, if badly treated, oftentimes as many months.

As the serum of the blood is yellow, and all the serous secretions are occasionally yellow, even to the semen and saliva, we can hardly feel surprised that Dr. Cheyne should mention the linen being sometimes dyed yellow by the perspiration; neither can we feel surprised that, to the jaundiced eye, "all things seem yellow." The patient, however, more commonly possesses his natural sight, and only in a few instances "sees yellow." Dr. Pemberton saw this phenomenon but twice. Dr. Elliotson also gives but two cases, or one in which the patient saw yellow with both eyes, and one in which he saw yellow with only one eye. The cause of this has been supposed to be the discoloured yellow serum circulating through the lenses and coats of the eye, or else that the aqueous humor must be tinged with the bile. The latter was examined in one case of a patient that saw yellow, but the colour of the humor was natural.

*Diagnosis.*—This disease is to be distinguished from chlorosis and that sallow state which results from profuse uterine hæmorrhage. In these complaints the white of the eye is blue, the urine limpid, and the stools healthy, so that the great characteristics of jaundice are wanting.

*Prognosis.*—In those cases of jaundice in which no mechanical obstruction or organic disease exists, the proportion of recoveries to deaths is large. Indeed, the restoration of the patient is almost certain. On the contrary, when it results from organic lesion, the death of the patient is much more usual than his recovery.

*Treatment.*—As a general principle, the larger number of cases of jaundice from functional disorder, perhaps four out of five, will get well on very trifling remedies. Two cases recently in St. Thomas's Hospital recovered by taking merely ℈j. of the carbonate of soda ter die, while two other cases recovered by taking the sulphate of magnesia ʒſs. to ʒj. with tinct. hyoscyami ♏ xv. out of camphor mixture, also three times a-day, and similar cases would perhaps do equally well on small doses of rhubarb or of castor oil.

It was formerly the practice to treat almost every case of jaundice by mercury; and, 30 years ago, hardly a case was admitted into St. Bartholomew's Hospital that had not been previously salivated, a circumstance which shows the extent to which this medicine has been tried, and that its exhibition is not by any means uniformly successful in the cure of this disorder. It is observed, also, when mercury fails, its effects are in many cases decidedly injurious; for a common jaundice is often turned into a black or green jaundice, which are the worst cases we meet with. There are a few cases, however, but perhaps not more than 1 in 9 or 10, in which the jaundice resists all other remedies, and yet is cured by mercury given in moderate doses, either of blue pill or of calomel, till the gums are sore. But the particular case is not to be distinguished by any peculiarity either in the history or symptoms from those that readily yield to more simple remedies, with only one exception, or the persons who almost live in a mercurial atmosphere, as the nurses of the foul wards, and these are often attacked with jaundice, and are only cured by the use of mercury. There is another class of jaundice, or that from ague, which readily yields to mercury, but, in case after case, resists a treatment by neutral salts.

As the cases which require mercury are few in number, it is desirable, in every instance, to treat every patient for 10 days or a fortnight with neutral salts, not only as offering the greatest number of chances of recovery, but also as sparing the larger number the unnecessary miseries of salivation. At the end of a fortnight, if no improvement be visible, it is then desirable to exhibit greater or less doses of mercury. In general five grains of blue pill once or twice a-day are sufficient, combined with some slight opiate.

There are cases which will not yield to the neutral salts ordinarily in use, and are only partially relieved by mercury; and in these instances the manganesii cum ammonio-sulphatis ʒſs. to ʒj. ter die, has often cured the patient when the preceding measures have failed.

In many cases the modes of treatment which have been mentioned are rendered much more beneficial if combined with some light vegetable or mineral tonic, as the infusi aurantii, cum tinct. aurantii ʒj. to ʒij., or else the tartrate of iron, 5 to 10 grains, may be added to each dose. The mineral waters of Cheltenham and Leamington, in which a neutral salt is naturally combined with iron, are known to be excellent remedies in most cases of jaundice.

Many practitioners make a practice of bleeding or cupping in almost every case of jaundice, a mode of treatment for which perhaps no sufficient reason can be alleged, for pain is seldom present, or any symptom to warrant it. It is a maxim, however, with Mr. Hill, in cupping jaundiced patients, not to cut deep; for although little blood flows in general while the cupping-glass is on, yet, shortly after it is removed, hæmorrhage often



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takes place, and there is great difficulty in stopping it. One patient in St. Thomas's Hospital recently died from this circumstance.

The diet of the jaundiced patient should be light; fish, puddings, and slops should be substituted for meat and poultry, and this abstinence should be persevered in till the patient is well.

### Of Gall-Stones or Hepatic Calculi.

Human bile has been analyzed by many modern chemists, and especially by Thenard, Berzelius, Vauquelin, Vogel, and Chevreul, but they have all arrived at different results. That by Berzelius is the most received, and is as folllows:—

| | |
|---|---|
| Water | 907·4 |
| Biliary matter | 80·0 |
| Mucus | 3·0 |
| Salts | 9·0 |
| | 999·4 |

Or, according to Thenard, it consists of—

| | |
|---|---|
| Water | 700·0 |
| A green resinous matter or peculiar principle | 15·0 |
| Picromel | 69·0 |
| Salts | 17·5 |
| | 801·5 |

In its healthy state it is of a deep yellow colour, extremely bitter, a little heavier than water, and miscible in that fluid in every proportion; and that in the gall-bladder is usually of the consistency of thin molasses. As it contains a little free soda it is alkaline, and its solid contents principally resolvable into a very large proportion of carbon and a small quantity of azote.

This fluid is liable to undergo many morbid changes; thus it is found green or yellow, and those colours may be pale or intense; or it may be as fluid as water, or as viscid as tar. Its taste is also greatly affected, it being sometimes bland, and at others so acrid as to excoriate the lip. These different states do not denote different states of the liver; for the same condition of bile is found in the most oppositely diseased states of the liver, so that they must be looked upon chiefly as resulting from diseases of function. The most remarkable, however, of the states of diseased bile is that in which it concretes into a gall-stone. The disease was known to the ancients, but the chemical composition of these calculi has been determined by the labours of the moderns, or by Fourcroy, Poultier, Powel, Chevreul, and others.

*Remote Cause.*—The remote causes of this disease are supposed to be too full an animal diet, combined with a sedentary life, or the indulgence of anger or of those other passions which suppress the flow of bile, and perhaps alter its qualities; also those states of indigestion which re-act on the liver. This affection, however, is not necessarily connected with ill health, for calculi have been found in the gall-bladder of persons who have died accidentally, and apparently in the best health.

*Predisposing Causes.*—This disease appears to be peculiar to adults; generally occurs after 20, but is, perhaps, most common between 40 and 60. It is supposed to affect women rather than men, and persons of sedentary rather than those of active habits of life.

*Pathology.*—Biliary calculi are often found filling the gall-bladder when the structure of the liver and gall-bladder is perfectly healthy; they are, therefore, a consequence of functional disease. Their principal seat is the gall-bladder, but they have been found "*in transitu*" in the cystic duct and in the ductus communis. Occasionally they have been found in the hepatic ducts, but so rarely that this fact is very generally doubted. Cruveilhier, however, has given one instance in his very splendid work on pathological anatomy, and Ruisch another. Lastly, they are sometimes found in the intestinal canal, after having passed from the gall bladder into that cavity.

Although the liver is frequently found healthy when the gall-bladder contains calculi, yet more commonly perhaps its structure is more or less diseased, and the lesion may be of every description to which that viscus is liable; thus it may be harder or softer, granular, or otherwise diseased. In some instances the ductus cysticus is obliterated, in others the gall-bladder is thickened or ulcerated; and if the body be examined shortly after a large gall-stone has passed into the intestine, the ductus communis, so small in health that it is difficult to find it, is then so enlarged as to admit the finger. In some very rare instances the extremity of this latter duct has been found obliterated from inflammation, in consequence of the irritation to which it has been directly or indirectly subjected.

The modern chemists have determined that gall-stones are composed principally of two substances, cholesterine and colouring matter, in various proportions, together with some animal matter, the usual salts, and perhaps a trace of iron. Cholesterine, which sometimes exists in the large proportion of 88 to 94 per cent. of the whole calculus, is soluble in boiling alcohol, æther, and in nitric acid. It is tasteless, inodorous, and burns by the flame of a lamp till it is altogether consumed. It is also lighter than water, and insoluble in that fluid. Its constituent elements give it much resemblance to ambergris, and are—

| | Cholesterine. | Ambergris. |
|---|---|---|
| Carbon | 72·000 | 84·088 |
| Oxygen | 6·666 | 2·914 |
| Hydrogen | 21·340 | 12·018 |
| | 100· | 99·020 |

The colouring matter, also, which is generally combined with the cholesterine, and often forms of itself a large portion of the gall-stone, is inodorous, insipid, and heavier than water. It is likewise insoluble in that fluid, in alcohol, or in acids, but is soluble in alkalies, whence it is precipitated, on the addition of water, of a brownish green colour.

The calculi found in the human gall-bladder have been divided by Dr. Powel into crystallized, deposited, amorphous, and porcupine calculi.

The *crystallized* concretions, when fractured, look like spermaceti, and the crystals, like those of that substance, are easily broken into a sort of greasy powder. They are in general semi-transparent, but seldom retain their purity throughout, being, near their circumference, coated or mixed with more or less of a brown colouring matter. At the central point of these colourless crystals, to which the radii converge, there is mostly a small particle of coloured matter, resembling dried bile, and which has served apparently as the nucleus of crystallization. Sometimes this crystallized shoot, having

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reached perhaps the size of a pea, becomes itself a centre around which many depositions are afterwards made of various confused and irregular strata, and the surface of these strata may in their turn become the nucleus of a fresh crystallization.

The *deposited* gall-stone is a deposition of biliary matter in laminæ, like the arrangement of an onion or of an urinary calculus.

The *porcupine* calculi are small round calculi, having a number of projecting points, and hence termed porcupine calculi. They are generally small, and their structure has not been determined.

The amorphous concretions are such as bear no mark of crystallization, or of any very regular structure, but sometimes as they dry they break into layers, showing their mode of formation.

Biliary calculi vary considerably in their specific gravity; and this does not appear to depend on any peculiarity of structure; for, two of the purest specimens being selected, one swam while the other sank in water —a difference perhaps owing to the greater or less quantity of animal matter they may contain.

These calculi vary greatly in number, or from 1 to 1000. When single they are usually of a round or oval figure. In size they vary from a pin's head to that of a nutmeg or a walnut; and Dr. Baillie has seen one as large as a hen's egg. When extremely numerous, they are usually small, of a dark brown colour, and occasionally slightly agglutinated with viscid bile. When, however, the number is small, or from two, three, to eight, the size often is considerable, and in this case the gall-stone is often made up of several, loosely adapted or fitted to each other, showing they must once have existed in a soft state.

With respect to the formation of gall-stones, the cholesterine, not being a constituent of healthy human bile, is evidently a morbid product, and is secreted in a fluid state. From this, if a nucleus of any kind, as a piece of thick mucus, be present, crystals may immediately shoot or form upon it; and thus a person apparently in good health may in an instant have a large gall-stone formed in his gall-bladder. Dr. Powel thinks he has met with cholesterine in a fluid state in the gall-bladder of a patient he examined. The peculiarity of this bile was its remarkably deep and almost black colour, whence he was led to treat it with alcohol, and in this manner he obtained solid cholesterine. The deposited gall-stone must be formed by an excess of colouring matter, or else by some morbid state of the bile, in which that principle is readily separable when any nucleus is present.

*Symptoms.*—The formation of the gall-stone is unattended with pain, and the stone, once formed, often lies latent for a considerable time. At length, however, some cause forces it into the cystic duct, when a series of very formidable symptoms arise, and which continue till the calculus has passed into the duodenum.

The attack is generally sudden, the patient being seized with shivering, accompanied by violent and acute pain at the pit of the stomach, or rather at the point corresponding to the opening of the duct into the duodenum, and from this point it darts through the back. This pain occurs in paroxysms, varying from a few minutes to a few hours, when it intermits, and after a short interval returns, and this continues till the gall-stone has passed into the intestine. The patient during this trying period suffers from nausea or vomiting so severe that everything is rejected, and the matters thrown up often contain bile and small biliary calculi.

Pain and vomiting are the leading features of the passage of a gall-stone, and it is impossible for those who have witnessed it not to be struck with the resemblance many of its symptoms bear to those of parturition—a comparison women frequently make when describing their sufferings. There is this difference, however, that when the pain intermits there is a deep-seated soreness and fulness of the right hypochondrium and epigastric regions. Like parturition, then, one attack of pain succeeds another, till at length this more urgent symptom ceases, and the calculus may be inferred to have passed into the intestine. After that has taken place, the soreness and uneasiness gradually cease, and the patient is restored to health. In some cases, and at some early period of the attack, jaundice makes its appearance, and continues for a considerable time after the calculus has passed.

The pulse during the paroxysm is for the most part natural, unless the patient is exhausted by long continuance of pain. The heat of the body also is often increased, but it is not the heat of fever. The dejections, according as the obstruction is more or less complete, are clay-coloured or natural, and, by a close examination, are ultimately found to contain the offending calculus.

The duration of the attack is very various, sometimes only a few hours, sometimes a few days, while sometimes several weeks elapse before the gall-stone is expelled.

It has been imagined that the degree of angularity of these concretions must considerably influence the symptoms; this, however, is not the case, for their angles are never sharp enough to cut nor their points to pierce. Size is of more importance than shape, and in proportion to its magnitude so will be the opposition to its passage. The transit of one concretion, by distending the duct, necessarily facilitates the passage of a second.

The symptoms which have been described are the most usual, but sometimes they are exceedingly anomalous. In one case, a lady was seized with violent pain in the left shoulder, simulating rheumatism. She then fell into a state of somnolescence so complete that even on the night-stool she slept and was obliged to be held. This state lasted for a fortnight, when she was seized with violent pains in the right hypogastrium, and, after some days, passed a gall-stone as large as an olive.

The symptoms which have been stated as a general principle cease on the gall-stone passing into the duodenum; but sometimes the calculus is so large as to give rise to severe disorder of the intestinal canal. A lady was attacked with symptoms of ileus, which gave rise to a suspicion of hernia, and an operation was about to be performed, when the patient most unexpectedly passed a stool in bed, which came away with a report like a pistol-shot. On examining the matters passed, a biliary calculus was discovered, $1\frac{4}{16}$ of an inch in length and $1\frac{1}{16}$ of an inch in diameter; it weighed 228 grains. The lady recovered.

*Diagnosis.*—The passage of the gall-stone is to be distinguished from hepatitis by the pains being in general of great intensity, and relieved by pressure, and also by the pulse continuing natural.

*Prognosis.*—The prognosis is always favourable,

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unless the calculus be of such magnitude as to render its passage almost impossible, or unless it be connected with organic disease of the liver.

*Treatment.*—When the symptoms of gall-stone passing the duct are present, the curative indications are to facilitate its passage into the intestine, to relieve the intense pain which accompanies it, and to prevent that inflammation which the presence of an extraneous body of any magnitude is calculated to produce in the duct.

The first thing to be done is to calm the sufferings of the patient, and a grain of solid opium, or a grain of morphine, or, what is still better, the mistura camphoræ, ℥ xj. conf. opii ℥ fs. to ℈ ij. c. sp. æth. nitr. ℥ j. should be given every hour or every two hours till some relief is obtained, and then exhibited every four or every six hours till the pain has ceased. Should the bowels be constipated, a drachm of the sulphate of magnesia may be added to each dose, or the bowels may be emptied by an enema of warm water, salt and water, or other medicament. If the vomiting be severe, and the above medicines be rejected, the opiate should be exhibited out of an effervescing draught.

Besides these medicines, a warm bath should be immediately prepared, and the temperature should be as high as 100° to 110°, or indeed as the patient can well bear it, and the immersion should continue till he is in some degree exhausted. The intention of the bath is to relax by means of heat the muscular fibre of the ducts, and thus relieve the pain and facilitate the passage of the gall-stone. Whether this theory be correct or not is unimportant; but the effect of the bath is always so agreeable to the feelings of the patient that, on the recurrence of the pain, he constantly asks for a repetition of it, and his wishes should be complied with. If a warm bath cannot be procured, fomentations, or a large linseed poultice should be applied over the abdomen. Dry heat is always at hand, and hot flannels, hot sand, or hot camomile flowers afford some relief.

Bleeding is supposed, during the passage of a gall-stone, to be injurious; for, by debilitating the muscular fibre, it is rendered more irritable, and consequently its contraction is irregular, morbid, and prolonged. It is a rule, therefore, not to bleed until the gall-stone has passed the ducts. When that is effected, if the side be extremely tender, and apprehension be entertained that the duct may have inflamed in consequence of the irritation it has suffered, a few leeches to the side, or a few ounces of blood taken by cupping are admissible, but this practice is rarely necessary.

The calculus having passed, and the patient being relieved, the secretions of the liver should, if possible, be rendered more healthy; and a short course of neutral salts, or of the Cheltenham or Leamington waters, or small and occasional doses of blue pill or of calomel, should be recommended as a means of rendering the secretion of bile more healthy; also, if the patient be of sedentary habits, he should be induced to take more exercise. Diet also has a considerable influence on the character of the bile. Children, from their simple diet, do not appear to suffer from this disease; and a simple diet, consisting of less animal matter and of smaller quantities of fermented liquors, should be adopted. Nothing can show more strikingly the effects of diet on the bile than by stating that when animals are fed on madder the bile is of a brighter tint, or if fed on sugar, that it approximates to that of herbivorous animals.

OF THE NEUROSES OF THE ORGANS OF RESPIRATION.

The diseases of function of the respiratory organs are, spasm of the epiglottis and glottis, aphonia, spurious croup, asthma, fœtid breath, and emphysema of the lungs.

*Strangulatio*, or spasm of the epiglottis and glottis, is a sensation of choking, more or less violent, preventing the introduction of air into the lungs.

*Remote Cause.*—Whatever causes an abnormal state of the muscles of these parts is a remote cause of this affection; thus the apoplectic patient has often died when eating from the food in his mouth pressing on the epiglottis—a mode of death not uncommon in the insane. Spasm of the glottis is a frequent symptom of hysteria, as may be seen by the patient constantly grasping the throat. It also occurs in children during the period of dentition, causing cerebral croup. Every structural disease of the larynx is a cause, as may be seen by the laborious breathing of the parties affected. Sometimes it is obviously the effect of the accidental admission of a particle of salt or of grease into the larynx, or other foreign body, as a bead or bean, a pebble or a shell, a fish bone, a button mould, a portion of a nut-shell, the stones of fruit, &c. The phenomena produced by these latter causes are so remarkable that we shall shortly trace them.

*Pathology.*—When a patient has fallen after a foreign body has passed into the trachea, the phenomena vary in some degree according to the size of the object and the duration of the disease. If the patient has fallen within a few days after the accident, the body, if small, is usually found in the ventricles, gripped by the chordæ vocales; and besides this little else is to be seen except a quantity of mucus and a slight redness of the bronchial membrane. In cases of longer duration, and especially when the body is large, it has in general been found in the right bronchus, for a line let fall perpendicularly from the centre of the larynx falls into that tube. In addition to this, more or less of inflammation has been found, sometimes ulceration, by means of which the foreign substance has occasionally made its way into the lung, and the patient has died of pneumonic abscess.

*Symptoms.*—The introduction of the foreign body into the larynx is always the result of accident, the substance being carried forward to the glottis by the act of laughing or crying, or else by the current of air in a strong inspiration. The first symptoms are an instantaneous sense of suffocation, the person or child becoming black in the face, and this is accompanied by a violent cough. This lasts till the patient is entirely exhausted by the effort of the lung to rid itself of this foreign substance. A calm of necessity follows, and the substance falls down into the bronchi, where it remains quiescent till the sensibility of the parts again accumulates and a fresh effort is made to throw off the offending cause, an effort so convulsive that it is difficult to conceive without witnessing it. It is singular how long an interval will sometimes take place between the paroxysms. In a recent case the little patient appeared quite well, played about, eat heartily, and slept soundly for a whole fortnight, when the fatal attack fixed the substance (a shell) in the ventricles, and carried him off. The fatal period, however, is often much longer delayed. Mr. Liston removed a fragment of a bone six months after it had been swallowed; while

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Mr. Sere speaks of a girl who coughed up the rump-bone of a chicken seventeen years after its introduction. Besides the severity of the paroxysm there is little else to denote this accident. In a late case (Mr. Brunel's) the stethescope gave no indication; and it will be plain, if the substance be of such magnitude as entirely to stop up the bronchus, air will be retained in the lungs, while, if it be smaller, air will still pass upwards and downwards, so that the lung will still give a healthy sound on percussion.

*Diagnosis.*—The difficulty of forming a diagnosis has already been stated.

*Prognosis.*—The danger in these cases is very great, from the fatal consequences which may follow a sudden return of the paroxysm. In a few cases only is the patient saved by coughing up the foreign body.

*Treatment.*—The treatment is by emetics, or substances that occasion violent sneezing, in hopes that the efforts thus occasioned may cause the expulsion of the foreign body. If this, however, should not take place after once or twice exhibiting these substances, tracheotomy should be performed, for, supposing the diagnosis to be erroneous, the operation is trifling and void of danger, while, if the foreign body be present, it is in general easily extracted; or should any difficulty occur in its removal, the case of Mr. Brunel shows that it may escape by its own gravity, by fixing the patient to a board and holding him up with his head downwards.

*Spasmodic Croup.*—*False croup* is a spasmodic affection of the larynx and glottis, by which a sudden hoarseness and difficulty of breathing, resembling the most aggravated symptoms of inflammatory croup, is produced. This disease, however, seldom lasts more than a few hours, when it subsides.

*Remote Cause.*—This affection rarely occurs except in children, and generally only after exposure to a cold easterly wind, or else after eating a very large, heavy, indigestible meal.

*Predisposing Causes.*—Every recorded fact seems to show this disease to be extremely rare, except in children under six years of age.

*Pathology.*—This disease seldom proves fatal, and the sudden subsidence of its formidable symptoms demonstrate it to be merely a disease of function.

*Symptoms.*—The symptoms are, that the child is on a sudden seized with a hoarse, crowing, sibilous breathing, loudest on inspiration, when his face becomes full and red or purple. The great distress of the child is manifest, but the pulse is quiet, and when proper remedies are applied it generally subsides in a few hours. The ratio symptomatum, when the disease occurs from indigestion, is, that the stomach being overloaded, the irritation of the gastric branch of the eighth pair is propagated to the laryngeal and pulmonary branches, and causes the difficulty of breathing.

*Diagnosis.*—Spasmodic croup may be distinguished from inflammatory croup by the suddenness of the attack, the quietness of the pulse, and the temporary duration of the disease.

*Prognosis* is always favourable.

*Treatment.*—In those cases in which the disease arises from sympathy with the stomach, an emetic is the best remedy; a drachm, therefore, of antimonial or of ipecacuan wine should be exhibited every quarter of an hour till vomiting is produced. As soon as the stomach is emptied the spasmodic breathing is relieved, and the paroxysm gradually subsides. The further treatment is to purge the child and put it on a light diet for a few days. When it results from a cold wind, the warm bath and free purging in general speedily restore the little patient.

*Aphonia* is when the larynx is so affected that the voice is wholly or partially lost, so that the patient is unable to speak except in a whisper.

*Remote Causes.*—The remote cause of primary aphonia is whatever affects the muscles of the larynx, as any overstraining of the voice in singing or speaking; cold or sudden changes of the weather; rheumatic affection of those parts is also a cause, as likewise all that impairs the nervous energy of the laryngeal muscles. Thus the voice is often lost after a paroxysm of hysteria or a severe mental affection. It is well known, also, that at the period of menstruation public singers lose two or more of their upper notes.

*Predisposing Causes.*—Complete aphonia is common to all ages, but is most common in early adult age, and more particularly in the female. In advanced age the change of the voice, and the general impairment of its tone and volume, is well known. Many singers who have compassed two octaves in their prime hardly perhaps preserve four feeble notes in old age; but this, perhaps, among other changes, may be owing to ossification of the cartilages.

*Pathology.*—An entire loss of the voice often takes place without any congestion, inflammation, or other structural lesion of the tissues of the larynx and glottis, and is therefore essentially a functional disease. When aphonia is secondary or symptomatic, tubercular or other structural diseases of the lungs are often found.

*Symptoms.*—In primary aphonia there is no tenderness or soreness of the larynx, no pain on pressure, and no expectoration, and the general health of the patient is good. It often comes on suddenly, and only in a few instances is the attack gradual. It often also disappears in a few hours, but in other cases it continues for some weeks and even months.

*Diagnosis.*—Aphonia is so marked a symptom, that though some doubt may exist as to the cause, none can exist as to the disease. It is distinguished from the aphonia in phthisis by the general good health of the patient.

*Prognosis.*—Primary aphonia is seldom of any moment. When it results from phthisis it is one of the fatal symptoms.

*Treatment.*—Primary aphonia, though a disease of little consequence, is often very difficult to cure. Sometimes attention to the general health will remove it. In other cases it yields to some local application, as blisters, mustard poultices, or the linimentum camphoræ, or other stimulating application. Dr. Elliotson sums up what can be done in these cases as follows,—"I do not know any better mode of treatment than the shower bath and attention to the improvement of the general health in every way you can." It should be remembered that this disease can be easily feigned.

The functional diseases of the lungs are asthma, fœtid breath, and emphysema.

*Asthma.*—Asthma is a laborious wheezing respiration, for the most part occurring in paroxysms, or, if constant, having exacerbations and remissions. 5183 persons are said to have died of this complaint in 1839 in England and Wales.

*Remote Causes.*—Whatever irritates the muscular fibre of the bronchial tubes, or impairs their nervous energy, or affects the secretions of the bronchial mem-

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brane, may be a cause of asthma. Every act of intemperance, either from accelerating the circulation, or from the sympathy which exists between the gastric and pulmonary branches of the eighth pair, is a cause. Every mental affection, also, either from acting on the heart, or from its exhausting the system generally, and consequently the lung of its nervous energy, is also a cause. Laennec speaks of a man who, probably from apprehension of an attack, could not ride across a plain. Temperature or weather has also a great influence in the production of this disease. Floyer says, a change from frost to thaw often caused him a paroxysm; also a change of wind from west to east. Rain, or snow, or fog, often had the same effect; and "I feel them," he adds, "even before they come on." He states, also, that he suffered sixteen attacks in winter and twenty in summer, but that the most violent paroxysms were in August. Van Helmont says, he has also observed asthma to be more frequent and more severe in summer than in winter, but adds, "I have likewise seen asthmatic patients who suffer more in winter than in summer." Indeed the asthmatic patient may be said to be—

> "But now of turbid elements the sport,
> From clear to cloudy toss'd, from hot to cold,
> And dry to moist, with inward-eating change.
> Our drooping days are dwindled down to nought—
> Their period finish'd ere 'tis well begun."

Sometimes asthma arises from inexplicable conditions of the air: thus, most people are better in the country; but some can only live in London in the narrowest and darkest streets; others are well in low and damp situations, surrounded by the smoke of steam-engines and the effluvia of lime-kilns; while others can only breathe on a high, open, and dry position. Again, asthma is often caused by some specific irritating cause. At St. Thomas's Hospital, the laboratory man cannot pound ipecacuanha without being seized with a fit of asthma which lasts him many days; while the smoke of tobacco, or the emanations from grass in flower, producing what is termed hay-fever, or hay-asthma, are causes of it in others. The impalpable dust inhaled by bakers, miners, leather-dressers, china manufacturers, or needle grinders, is often a cause. Every structural disease of the lung is also a cause, and asthma is consequently an occasional accompaniment of phthisis.

*Predisposing Causes.*—This disease sometimes occurs in children under ten years of age, but these cases are extremely rare. It is not unusual between twenty and thirty, but is most common after fifty. Women in this country suffer in a less proportion than men, 3092 having fallen of the latter to 2091 of the former. Frank, however, says in his experience, that males suffered more than the females in the ratio of six to one. In young women the attack is most severe about a week preceding menstruation. The aged, indeed, of either sex, are seldom altogether free from it, and this appears to be chiefly owing to the physiological changes which take place at this period of life, the tissue of the lung becoming more rare, its cells larger, and its capillary blood-vessels obliterated; while the innervation of the eighth pair is very generally impaired, and thus the foundation of the disease is laid in organic alterations. Asthma appears in many instances to be hereditary, and to descend through two or three generations.

*Pathology.*—In proof that this affection is merely a disease of function, the bodies of many persons have been examined without the lungs being in any sensible degree diseased. Persons, however, affected with this complaint have in general very delicate lungs, and suffer much from bronchial inflammation, and the mucous membranes are consequently often congested. The cough is also often of unusual violence in this disease, and the lungs are therefore sometimes found emphysematous. In the aged, asthma is very constantly combined with disease of the large arteries, and more especially with disease of the left side of the heart, and in this latter case the asthma in all probability arises from the sympathy which exists between the cardiac and pulmonary branches of the eighth pair.

*Symptoms.*—Asthma has been divided into three kinds, or into dry asthma, humoral asthma, and purulent asthma; but these different forms of disease run very constantly one into the other. In general it is paroxysmal, but sometimes it is continued.

The dry asthma is a continued difficulty of breathing, with a loud wheezing respiration, increased by every attempt at bodily exertion, but without any affection of the mucous membrane of the lungs. This disease is common to old people, especially those whose heart and arteries are affected; and the difficulty they experience in walking or in ascending a flight of stairs, "for want of breath," is well known. More commonly, however, the mucous membrane is affected in asthma either with an abundant serous expectoration, or else with a more or less copious secretion of pus; but in either case the peculiar symptoms of asthma are not changed. Floyer, who laboured under this disease for thirty years, thus describes his sufferings during the paroxysm.

"For some hours preceding the fit of asthma, the patient experiences a sense of straitness, a fulness about the pit of the stomach, and is much troubled with flatulency; at the same time there is a heaviness of the head, drowsiness, propensity to yawning, and a discharge of pale urine. If these symptoms come on towards the afternoon they are followed at night by a tightness straight across the chest, and oppression of the breath and some wheezing. There is generally, too, convulsive cough, with little or no expectoration. In the course of the night the symptoms become more urgent, the inspirations are made with the utmost labour, the chest and shoulders being lifted up with great violence, and in a convulsive manner. In this distressing state the patient is often necessitated to get out of bed and to remain in an upright posture. Although the expirations are not so difficult as the inspirations, yet they are performed very slowly and with a wheezing noise. In this stage of the fit a person can neither speak nor cough. His face appears pale or livid, his hands and feet are cold, and his pulse is generally weak and irregular. He has a great desire for fresh air, and is much oppressed by a close heated room, by dust, smoke, or bad smells, and even by the weight of the clothes upon his chest. After some continuance of the attack headache is superadded to the other symptoms, and, the pulse becoming somewhat accelerated, there is a slight degree of feverishness. As the fit declines there is a discharge of wind both upwards and downwards, and frequently a motion to stool; the expectoration, also, at first, perhaps, difficult, becomes freer, and the urine, which before the fit was pale, is now high coloured, and deposits a sediment,"—a change which seems to imply that asthma is a constitutional rather than a local disease. Such are some of the most prominent symptoms

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of a paroxysm of asthma, which is more or less frequently repeated. In the worst cases a painful and most distressing angina pectoris aggravates the sufferings and increases the danger of the patient.

On inspecting the chest of a patient labouring under a severe paroxysm of asthma, the whole upper part seems almost motionless, while the inferior portions are acting within a very confined range. The abdominal muscles, however, act most powerfully. The stethescope teaches us that the whole of the lungs, but particularly the posterior lungs, are labouring with a loud and deep sibilous sonorous wheeze, accompanied with a mucous rattle, sometimes loudest on inspiration and sometimes on expiration. Percussion shows the lung is distended with air; and should an air-cell have burst, a rubbing sound will be heard, denoting the effusion of air into the cellular substance of the lung. As the fit subsides the respiration becomes puerile, and by degrees the breathing returns to its usual state. In fatal cases the respiration becomes tracheal, slight hæmorrhage perhaps takes place, and after a severe struggle the patient falls.

The duration of the fit is very various, for in some cases it lasts a few minutes, in others two or three hours, in others the whole night, in others three or four days, and in others as many weeks.

The frequency of the recurrence of the fit is equally various; sometimes it occurs every night, sometimes every few nights, and at any longer period. The late Dr. Heberden remarked that some asthmatics experience four attacks in the year, others only two, or in spring and autumn, and others again only one attack in the year, and that in winter.

*Diagnosis.*—The disease with which asthma is most likely to be confounded is a sudden effusion of water into the chest, from which the dulness, on percussion, together with the ægophony, readily distinguish it.

*Prognosis.*—The prognosis of any given paroxysm is always favourable. Many persons attain old age though suffering many years from asthma. There can be no doubt, however, of its acting unfavourably on the general health, and that it tends to shorten life and predisposes many to apoplexy. When it occurs in early life the patient often gets rid of it.

*Treatment.*—The treatment comprises what should be done during the fit and what should be done to prevent its recurrence.

The dry asthma is seldom severe, or else sympathetic and connected with disease of the heart. In the first case slight opiates and expectorants are sufficient. In the last, relief must depend on the success which attends the treatment of the primary disease.

When the patient is labouring under a fit of either of the other forms of asthma, our efforts must be directed to tranquillize his suffering and to shorten the attack; but so capricious is this disease, that what will benefit the patient in one attack will be of little use in another. As a general rule, however, the patient should be supported, and mist. camphoræ, ℥ iss., sp. ætheris nitr., ʒ j., c. confect. opiatæ, ʒ ss., given every hour, or every two hours, for a short time, are among the best remedies. If the head should be affected by the opium, some milder narcotic should be substituted, as tinct. hyoscyami, ♏ xv. or syrupi papaveris, ʒ j., which latter agrees with everybody. In other cases, or in other attacks, assafœtida, castor, musk, or hydrocyanic acid, ♏ iij. $6^{tis}$ may be substituted. Again, if the fit should occur after a hearty meal, some purgative should be given to empty the stomach, or the tinct. rhei, or the sulphate of magnesia in ʒ j. doses. If the attack be long, arrow root or sago, with small quantities of wine or brandy, should be given to support the patient under this laborious and exhausting attack.

With respect to emetics, the exhaustion they produce is seldom compensated by any long-continued alleviation. Expectorants for a time perhaps relieve the patient, but long continued they impair digestion, create flatulency, and are at length abandoned.

The feelings of the patient should be consulted as to the temperature to which he should be exposed during the paroxysm. In general, where there is organic lesion of the heart and large vessels, the fresh air is extremely grateful and reviving, its coldness giving power to the circulating organs, and by lowering the temperature of the body enables the patient to live on a smaller quantity of oxygen. It is on this principle that the dog asphyxiated by the effluvium of the Grotto del Cane is thrown into the water, he being able to breathe at the temperature of the water when he would have died at the temperature of the atmosphere. The toad, also, when cooled down, will live encased in plaster of Paris, but if his body has a high temperature the experiment is fatal. On the contrary, when the disease is purely pulmonary, warmth, by relaxing the spasm of the bronchial vessels, is generally more useful than cold. It is singular, also, that experiment has shown that animals can live for a short time at a high temperature on a smaller quantity of oxygen than usual,—the rarefaction of the air hardly allowing the arterial blood to undergo any change in the capillary system.

The treatment during the interval must depend very much on the age and pathological state of the patient. In young persons, whose constitution is sound and habits temperate, much benefit will be found from warm tonics and attention to the general health; while in humoral asthma small doses of mercury, or squills, or the tinct. lobelia inflata, are supposed greatly to assist the patient; and in disease of the heart, camphor mixture, sp. ætheris nitrici, and small doses of digitalis are proper. There are a certain class of cases, also, though not accurately determined, which are much benefited by quina.

The inhaling of oxygen, hydrogen, and hydro-carbonated gases has been tried, but with little benefit; and so also of the smoke of stramonium, or other narcotic drug. Blisters are often useful both during the paroxysm and in the interval.

The diet of the patient should be light; he should also wear flannel, and guard himself from cold and wet, especially in his feet. When the disease is prolonged, change of air ought always to be had recourse to.

*Emphysema of the Lung.*—Emphysema of the lung is the extravasation of air into the cellular tissue of the lung, either in consequence of a secretion, or of the rupture of an air-cell. Dr. Baillie has described this disease, and Laënnec has connected it with its symptoms.

*Remote Cause.*—The cause of emphysema is often mechanical, and probably arises from the glottis becoming so strongly contracted in a fit of severe coughing, that the muscles of expiration are unable to overcome this obstacle, and consequently some of the air-cells give way, and the air escapes into the cellular tissue of the lung. In other cases it is a primary disease, the air being perhaps secreted into the cellular tissue in the agony of death. The remote causes of emphysema,



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therefore, are also those causes which produce cough, and the debility of the last agony of life.

*Predisposing Causes.*—This disease is occasionally met with in children labouring under hooping-cough, but is most common in middle and advanced age.

*Pathology.*—In emphysema of the lung, the size of the cells is increased and their form rendered irregular by the extravasation of air. The magnitude of these cells varies greatly, or from a millet-seed to an egg, the larger sized ones being formed by the rupture and communication of one or more cells. The rupture of the cells often detaches the pleura, and permits it to rise above the level of the lung to a considerable extent, so that the affected part has some resemblance to a bunch of currants or of grapes, and that portion of the lung does not collapse, but rather protrudes on opening the chest. In some instances the air escapes through the bronchi on pressure, but more commonly no such effect takes place, showing that the air has been secreted and not extravasated by rupture of an air-cell. Emphysema is found combined with many inflammatory affections of the lungs.

*Symptoms.*—This disease, it has been stated, occurs only with severe cough, and, strange to say, after its occurrence the cough seems hardly aggravated. It is only determined to be present by auscultation, when it is denoted by a rubbing sound as the lung ascends or descends. Laënnec also adds, a "râle erépitant sec à grosses bulles." These are the symptoms.

*Diagnosis.*—In pleurisy there is also a rubbing sound. It is distinguished from this disease by the absence of pain.

*Prognosis.*—Laënnec conceives this disease to be much less grave than might be supposed, for he affirms the air may be absorbed, and the cells heal, leaving a cicatrix. He thinks he has seen many recover, and many certainly do recover after the rubbing sound is present.

*Treatment.*—When it does yield it is to the general treatment of the cough.

### Of Fœtid Breath.

*Remote Cause.*—A disagreeable taint of the breath often occurs in ill health of whatever nature, but it also sometimes occurs in the best health, and without any assignable cause.

*Predisposing Causes.*—This affection often attacks children and adult persons of every age and of both sexes.

*Pathology.*—Andral gives a case of a person who suffered from an extremely offensive breath, and whose body he examined, but without discovering any organic lesion of any kind. This affection is therefore entirely a disease of function. The lungs, indeed, are one of the organs by which many substances which mingle with the blood are removed from the body. If a person eat onions, it is not solely because they are in the stomach that the breath smells of them, but because the odorous principle is absorbed and mingles with the blood, and is removed by the lungs. It is the same with alcohol, which is equally given off by the lungs. Again, if phosphorus be injected into the veins, and the animal be placed in the dark, it seems to breathe flames of fire. The lung, therefore, is a secreting organ, and those secretions, like those of other parts of the body, may become diseased and give rise to fœtid breath.

*Symptoms.*—The symptoms are too marked to need any description. The degree, however, to which the breath may become tainted is quite remarkable, for in some cases it is so putrid as to resemble the odour of gangrene. A man in St. Thomas's Hospital, though otherwise in good health, laboured under this disease to such an extent, that, although he was surrounded with chlorides and aromatics, it was impossible to go near him. A very interesting young lady, who likewise suffered from epilepsy, had so intolerably a fœtid breath that nobody but her own mother could be found to enter her room or to nurse her.

*Diagnosis.*—It is distinguished from gangrene of the lung by the health not being in any corresponding degree impaired.

*Prognosis.*—This affection, except in extreme cases, is rarely grave. When the fœtor, however, is intolerable, it is often the forerunner of severe disease, and ends fatally.

*Treatment.*—In slight cases, gentle purgatives and attention to the general health are sufficient to remove this affection, but for the severe cases that have been mentioned no remedy has been discovered. Surrounding the patients with the chlorides, and with boiling vinegar mixed with aromatics, is some relief to the attendants, but in no degree influences the disease itself.

### Of the Neuroses of the Heart.

The neuroses of the heart are angina pectoris and palpitation.

*Angina Pectoris* is an extremely agonizing pain of the anterior portion of the chest and neck, extending to the shoulder and down the arm.

This disease had attracted little attention, till Dr. Heberden, about seventy years ago, 1772, drew the attention of the profession to it by two papers published in the second and third volumes of the *Transactions of the London College of Physicians.* He connected it with disease of the heart, and it has ever since been treated of in conjunction with the disease of this organ. It has subsequently been studied by Drs. Black, Parry, and Jenner, and by many continental physicians.

*Remote Cause.*—Every severe functional or structural affection of the heart or lungs lays the foundation of this complaint, and the foundation once established, every atmospheric vicissitude, error in diet, or moral or physical exertion, will bring it on. Mr. Hunter, who suffered greatly from this disease, used to affirm that his life was in the hands of any person or circumstance which acted powerfully on his mind, and, in fact, he ultimately died from strong but suppressed feelings on a point in which he was interested. Ascending a staircase or other acclivity, or indeed any active exertion, is a powerful exciting cause.

*Predisposing Causes.*—Age has a powerful influence in the production of this disease, for it rarely attacks children unless affected with rheumatism or other disease of the heart. It is not uncommon, however, in early adult age in the paroxysm of hysteria. The aged, however, suffer the most, for out of eighty-four cases noted by Dr. Forbes seventy-two were above fifty and twelve only under fifty. Males have been observed to labour under this affection more frequently than females, or of eighty-eight cases eighty were males.*

*Pathology.*—Angina pectoris being present in many cases of hysteria and of simple palpitation of the heart, and also of idiopathic asthma, it is plainly often a

* *Encyclopædia of Practical Medicine*, Art. 'Angina Pectoris.

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merely functional disease. It exists, however, with most of the organic diseases of the chest, and Dr. Forbes finds in different authors from the time of Heberden the following results, from the examination of forty-five bodies of persons who had suffered from this affection. Of this number there was obesity in four, but no disease; organic disease of the liver existed in two, while organic disease of the heart or larger arteries existed in thirty-nine.

*Symptoms.*—The attack of this disease is generally sudden, and is characterized by a constrictive anxious pain, fixed most commonly on the left lower half of the sternum, and rarely extending above the fourth rib. Occasionally, however, and especially in rheumatism, it extends over the whole anterior portions of the chest, along the neck to the lower jaw, into the back and shoulder, down the arm to the elbow, and even to the hand and fingers—a course which shows it to affect externally the superficial cervical plexus and its ramifications, as well as the anterior thoracic nerves, the cubital nerve, and its divisions. The pain is also sometimes sub-sternal, and then follows a course which shows that the nervous plexus placed between the folds of the mediastinum, and also the branches of the eighth pair, which go to the large arteries and surround the bronchial tubes, are affected, explaining the cause why the pulse is sometimes rapid, sometimes hardly to be felt; also why the breathing is greatly accelerated, or else imperceptible. Mr. Hunter, when labouring under the paroxysm, could scarcely feel his pulse, and thought he should die unless he exerted his voluntary muscles to carry on respiration, and many have died literally asphyxiated. Darwin has also seen the action of the diaphragm, and consequently the phrenic nerves affected, while Laënnec mentions that the lumbar and sacral nerves also partake of the same disease, which in some measure explains the fact of the urine being sometimes suppressed during the paroxysm. Besides the parts which have been mentioned, the gastric system is also much affected, the patient perhaps being in an instant distended with wind, and only relieved by repeated eructation. In all cases, where the patient is not broken down by disease, the mind is clear, but the face and extremities are cold and pale. At length the paroxysm subsides gradually, when much wind is discharged, accompanied by a copious and almost involuntary flow of pale limpid urine, and the patient recovers.

The time of the attack is extremely uncertain; in asthmatic cases it is often about two o'clock in the morning; while in other cases it occurs at any period of the day or night.

The duration of the fit is very various, for sometimes the pain only lasts a few minutes, while at other times it will continue for two or three hours, a whole day, or even longer. The interval is likewise very uncertain, or from a few hours to a few days, or a few months. Each repetition, however, increases the tendency of the paroxysm to return, and also its violence; and at length, perhaps, an aggravated attack occurs, and puts a period to the patient's existence.

*Diagnosis.*—The diagnosis of this disease is palpable.

*Prognosis.*—Angina pectoris, when a primary disease, or the result of hysteria, &c., is rarely fatal. When it is a secondary affection, the danger is in proportion to the nature and degree of the organic lesion on which it depends. If the lesion be of a dangerous character, the angina denotes a paroxysm of unusual severity, and is always a symptom of danger. Dr. Forbes says, of sixty-four recorded cases of angina, forty-nine died, and almost all of them suddenly.

*Treatment.*—The indication for the treatment of angina pectoris is to support the patient by mild stimuli, as æther, camphor, and by moderate doses of opiates, assisted by a small quantity of wine or brandy and water. If the attack has been preceded by a hearty dinner, some warm purgative, as the decoct. aloës comp., or perhaps an emetic should be exhibited. The paroxysm past, we must look to amend the general health of the patient. The organic affections, however, are generally of an irremediable nature.

During the paroxysm the patient will find a recumbent posture, fresh air, and perfect quiet, greatly contribute to restore him. Dr. Forbes gives a case in which the party was seized on horseback, when, continuing his course, he fell dead off his horse.

### Of Irregularities of the Heart's Action.

The heart may beat abnormally slow, may intermit, may have a rolling action, or its pulsations may be so frequent, and its action so irregular, as to be termed *palpitation*. These states are all caused by an irregular innervation of the heart, by which it is rendered morbidly sensible or insensible to its natural stimulus, the blood. The excessively slow pulse is often caused by some pressure made high up in the cervical portion of the spinal cord, or else by congestion or pressure on the brain. The other states are perhaps inexplicable, and may be considered as ultimate facts. The irregular and rolling action of the heart is, in general, accompanied with hypertrophy, or other disease of that organ, and will be best treated of under those heads of disease. Fits of palpitation, however, may occur in the most healthy subjects, and in the most healthy hearts, and this neurosis of the heart is the only one of which we shall now treat.

*Palpitatio* is an abnormal innervation of the heart, by which its actions are rendered often highly irregular, and its pulsations remarkably increased in frequency.

*Remote Cause.*—The excitability of the hearts of young people is readily accumulated and as readily exhausted. Everybody is aware how powerfully every passion and every affection acts on the heart and changes its healthy beat; as also how every error in diet, or any over-exertion, may produce the same effect. Every moral, as well as almost every physical cause, may consequently be the remote agent in the production of palpitation, while every pathological state of the heart may be accompanied by it.

*Predisposing Causes.*—This affection of the heart, as a primary disease, seldom occurs before puberty, but after that period it is common, and often to a most distressing degree in both sexes. The female, however, suffers more than the male, and especially during amenorrhœa, or at the period of menstruation, and in more advanced life when menstruation ceases.

*Pathology.*—That palpitation is merely a disease of the function of the heart, is evident from the number of young persons who suffer from it, and who afterwards attain a hale old age. Laënnec says it is generally believed that habitual palpitation of the heart at length terminates in hypertrophy or dilatation of that organ; but he adds, "I have seen nothing to establish this fact." Palpitation, however, is a symptom of every disease of the heart, and consequently every diseased



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Elementary Principles of Medicine.

state of the heart is found concomitant with this affection.

*Symptoms.*—The attack of palpitation may be sudden, or it may be preceded by acidity, flatulence, or other affection of the stomach. It has many degrees. In young persons of a delicate constitution it often occurs in a slight degree nightly; so that the patient, on going to bed, passes many hours sleeplessly, not only feeling his heart beat but also hearing it. His subsequent sleep is unrefreshing, and he awakes in the morning more tired and jaded than when he went to bed.

In some cases, as in young women labouring under leucorrhœa, the palpitation is constant, the pulse beating for many weeks at 150 to 180 strokes in a minute. In other cases it is paroxysmal. When the paroxysm is formed, the pulse may still preserve a regular rythm, only greatly increased in frequency, while its force may be increased or diminished. In the severest cases, however, the pulse is so rapid that it has a mere vibratory motion, and cannot be counted, while its rythm is extremely irregular. The force of the heart's action also is now excessive, and now not to be felt. In general the contraction of the ventricles is so rapid that it is impossible to hear the sound of the auricles; and again, so singularly irregular is the action of the heart, that the auricles may contract at the same time as the ventricles, or perhaps contract three or four times for the ventricles' once; and indeed the heart appears to act with every possible degree of irregularity. In general the other branches of the eighth pair are affected besides the cardiac branch, for the patient often becomes distressingly distended with flatus, and that almost on the instant, while his deep sighing shows the pulmonary as well as the gastric branch to be involved. The patient having lain in this state, pale, anxious, and restless for a greater or less length of time, the fit at length terminates, and the pulse perhaps is restored to its natural frequency and healthy rythm as instantaneously as it had lost them. The patient now passes a considerable quantity of pale limpid urine, and, though feeble from exhaustion, is once more able to sit up and so far to exert himself.

The duration of the paroxysm is very various; sometimes it lasts a few minutes, sometimes a few hours, while Laënnec speaks of a paroxysm connected with organic disease which lasted a week. The interval between the paroxysm is also uncertain. In young persons it may occur every twenty-four hours two or three times a week, or every month; or a still longer period may elapse.

*Diagnosis.*—The fact of palpitation cannot be mistaken.

*Prognosis.*—Palpitation is seldom dangerous, unless conjoined with organic disease of the heart, and when merely an idiopathic disease, it frequently subsides as the patient advances in life.

*Treatment.*—During the paroxysm the patient should lie flat on his back, bare his neck and chest, and allow the air to blow freely over him. The best remedies are camphor mixture and æther ʒi., with some slight opiate, as the syrup of poppies ʒj., or else tinct. hyoscyami ♏xx.; and this should be repeated every quarter, or every half hour, or hour, according to the severity of the attack, till the heart's action is stopped. Cold brandy and water, as it is always at hand, is an excellent substitute for, or adjuvant to, that medicine. Again, if the attack occurs shortly after a meal, some purgative medicine should be given to clear the stomach.

The paroxysm past, the patient, though much exhausted, speedily recovers his usual health, which is generally feeble. It is useful, however, to continue the medicines which have been mentioned, but at longer intervals, for some time. It is important in these cases, however, to counsel the patient strictly as to diet, for without such auxiliary assistance medicine is often of little service. On questioning these patients, we constantly find that the palpitation returns after tea or after breakfast, or whenever hot tea or hot coffee has been drank, and in these cases it is extremely desirable to wean the patient from all hot slops, and to induce him to drink cold water at his breakfast and indeed at every meal; his wine also should be limited to two or three glasses of sound sherry, and should be drank diluted with water. There are few tonics so beneficial as the natural tonic of cold water, and persons once accustomed to it feel a return to a modern breakfast as a punishment rather than a gratification.

### Of the Neurosis of the Urinary Organs.

The kidneys are the organs by which ten-elevenths of all the azote introduced into the system, as aliment, is discharged. They are also the means by which a large portion of the fluids, all the phosphates, as well as many extraneous substances received into the circulating system, as turpentine, copaiba, myrrh, iodine, rhubarb, the odoriferous particles of asparagus or of buchu, are removed from the body. In health, the specific gravity of the urine varies from 1015 to 1025, and the following substances, according to Berzelius, are found in it:—

| | |
|---|---|
| Water | 933·00 |
| Urea | 30·10 |
| Uric acid | 1·00 |
| Mucus | ·32 |
| Lactic acid, free lactate of ammonia, animal matters soluble in alcohol | 17·14 |
| Sulphate of potash | 3·71 |
| Sulphate of soda | 3·16 |
| Phosphate of soda | 2·94 |
| Phosphate of ammonia | 1·65 |
| Muriate of soda | 4·45 |
| Muriate of ammonia | 1·50 |
| Earthy matters | 1·00 |
| Silex | 0·03 |
| | 1000 |

Such is a general view of the composition of human urine in its healthy state. But this fluid is subject to a great variety of morbid conditions. Its quantity may be greatly diminished or increased, or it may be suppressed altogether. The usual salts, as the urea, the urates, and the phosphates, may be in great excess, and hence lay the foundation of those distressing complaints, stone and gravel; or they may be in great defect, as in most nervous disorders. Besides these alterations in the proportions of its healthy constituents, urine may contain many morbid secretions, and, strange to say, this acrid fluid is sometimes sweet, containing a considerable portion of sugar, causing the disease termed diabetes mellitus. The other morbid secretions of the urine are oxalic acid, giving rise to the mulberry or oxalate of lime calculus, and those substances termed cystic oxyde and xanthic oxyde. Albumen also very commonly

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exists in large quantities in the urine; but this latter disease, when of any extent, is so constantly accompanied by disease of the kidney and by dropsy that we shall treat of this particular affection under the head of dropsy.

The average quantity of orine discharged daily in health is estimated to be about thirty-five ounces. When this quantity is greatly in defect the disease is termed anoria; when in great excess it is termed diabetes iosipidus.

*Anuria; ischuria renalis* is a complete or partial suspension of the functions of the kidney, by which the quantity of urine is greatly in defect, or its secretion entirely suppressed. One hundred and sixteen cases are said to hava died of this affection in England and Wales in 1839.

*Remote Causes.*—This affection may be caused by disease of the kidney itself, or it may be secondary, and arise from disease in other parts of the body. Among the latter are injuries of the head or spine, an affection of the brain in fever, an attack of pneumonia, when the patient will sometimes hardly pass a few ounces of urine in twenty-four hours, or of hysteria, when it is often suppressed for several days together, and also of inflammation or high irritation of the bladder. When the disease is idiopathic it may depend on inflammation of the kidney, caused perhaps by some poison acting on that organ, as that of small-pox, or else by cantharides, or turpentine. Anuria is also caused by those many undefined conditions of the kidney which produce dropsy. The presence of a calculus also in the kidney or the ureter is also an occasional remote cause.

*Predisposing Causes.*—All ages are liable to this affection; children from teething often suffer a complete suppression, or only pass a few drops of fiery urine in the twenty-four hours; the adult from gravel or stone; and the aged from disease of the brain or cord. Both sexes equally suffer from it, and especially when labouring under dropsy.

*Symptoms.*—The existence of complete anuria is palpable, the patient passing no urine; and, again, if the catheter be introduced, no urine flows through it. When the suppression of urine is merely symptomatic the symptoms are little marked, being lost in the greater disease. The patient, however, may complain of some pain in the back, of some irritability of the bladder; he then becomes anxious and restless, till at last the brain is oppressed, and he dies comatose. In other cases there is nausea, hiccough, and the body exhales an urinous odour. When the suppression is less complete, and depends on an affection of the bladder, the local sufferings of the patient, the forcing of the bladder, the tenesmus, and the general irritation of the poor sufferer are most severe and distressing.

The time during which the urine may be suppressed, and yet the patient recover, is very various. Children when teething often void only a few drops of urine, and that at several hours' interval. The urine passed at such times is extremely high-coloured, stains the linen, and is passed with great pain, the child crying bitterly as it scalds the surface over which it flows. In hysteria the urine is often suppressed for three or four days. Dr. Laing, of Fochabers (*Edin. Med. and Surg. Jour.*, vol. x.), gives a case in which no urine was secreted for nine or ten days, and yet the patient did well. As extreme cases, Dr. Parr, in his *Medical Dictionary*, mentions a patient who made no water for twenty-two weeks, while Dr. Richardson speaks of another who up to seventeen years of age had never passed a drop of water in his life. In this case the ureters must, as in birds, have terminated in the large intestine, and the urine have been passed with the fæces. In general, however, it may be laid down as a maxim, that when suppression of urine depends on any acute or severe disease the patient seldom survives this symptom more than three or four days.

Among the symptoms mentioned by authors of the suppression of urine is an urinous odour of the perspiration from the axilla and umbilicus, and they have accounted for it by supposing the urine to be first secreted and then absorbed. Much doubt hangs over these cases, for the suppression perhaps is not complete —a few drops wet the bed, the hand becomes impregnated, and an urinous smell is thus imparted to distant parts of the body. It is certain also that some of these cases are feigned; some women, for instance, are said to have had a vicarious discharge of urine from the stomach, and Nysten gives the case of a girl who vomited urine, but it was at length ascertained she first swallowed it. Another girl vomited not only urine but well-formed fæces, but it was also discovered that she first swallowed them. Rayer gives a similar case of a woman at La Charité, who had an abdominal tumor, which was supposed to be connected with the kidneys. Many persons saw her vomit urine, and Guibourt detected it chemically in the matters thrown up, but, strange to say, she had first drank it, though for what motive, except notoriety, nobody could imagine.

*Diagnosis.*—This disease is to be distinguished from mere retention of urine in the bladder, or from ischuria vesicalis, by there being no fulness in the vesical region, and by no urine flowing when the catheter is passed.

*Prognosis.*—Many cases recover from a suppression of urine of not more than twenty-four to forty-eight hours, but, except in hysteria, few survive if the disease continues a longer period.

*Treatment.*—When anuria is idiopathic and primary the patient should be placed in a warm bath, and be purged by substances that act on the kidney, as the neutral salts. Indeed, if the case be slight, purging by any cathartic is sufficient. If this method should not succeed, ♏ x. to xxx. of the tinct. cantharides should be tried every four or six hours, according to the urgency of the case. Many physicians, however, prefer a tonic treatment, as the camphor mixture and æther, the haustus olei cum manna, or the tinct. ferri muriatis, ♏ xxv. to ♏ l.

The treatment of symptomatic anuria resolves itself entirely into that treatment which will remove the primary disease.

### Diabetes Insipidus

Is a considerable excess of the urine, so that instead of thirty-five ounces it amounts to several pints in the course of the twenty-four hours. There are two forms of this disease, or Hydruria and Azoturia.

*Hydruria* is a copious discharge of limpid watery urine, containing the usual ingredients, but small in proportion to the quantity of urine passed, so that its specific gravity varies from spring water, or 1001 or 1002 to 1008 to 1010.

*Remote Causes.*—The causes of this affection are probably the usual general causes acting upon a highly nervous temperament, it having been observed princi-

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pally in hypochondriacal persons of feeble constitution, and whose diet has been low, or who have been much exposed to the accidents of life.

*Predisposing Causes.*—Hydruria has been met with by Dr. Watson, in a boy aged thirteen, who passed nineteen pints of urine daily of the sp. gr. of 1002. It is more common, however, from twenty to forty, and again in old age, and particularly in old men.

*Pathology.*—In such cases as have fallen at the early periods of life, the kidneys have been found healthy. In old people it appears associated with organic disease either of the kidneys or neck of the bladder.

*Symptoms.*—The leading symptom, or an excess of pale urine, is palpable, and cannot be mistaken, and on examination the fluid passed is found to be either neutral or to have only a faint acid re-action. A patient aged twenty-six fell under the care of M. Peschier, who passed ten to twelve pints of urine daily, of a light citron colour, of an urinous odour, and which still reddened vegetable blues. On analysis, the quantity of urea was trifling, ninety ounces of this urine yielding only 1095 grains of solid extract, instead of 3000 grains. Dr. Storch gives a case in which eight to twelve pounds of urine were passed daily, and in which there was hardly a trace of urea or of any of the usual salts. Dr. Willis also gives the case of a boy three and a half years old, who drank about four pints in the twenty-four hours, and whose urine was as near as possible of the specific gravity of distilled water, and 100 grains evaporated left but the fraction of a grain of solid residue. The specific gravity of the urine, which in health may be taken at 1010 to 1020, sinks in this disease to 1002.

The general health of these patients is always feeble. In person they are emaciated, pale, and often complain of pain in the back.

*Treatment.*—The treatment of this disease is by mild opiates, tonics, and attention to the general health.

*Azoturia, Diabetes Insipidus.*—In this form of disease the quantity of urea which exists in healthy urine in the proportion of 30 parts to 1000, and amounting to about an ounce and a half in the twenty-four hours, is often increased five-fold, to 150 parts in 1000, or to seven ounces and a half in the twenty-four hours, while the specific gravity is raised from 1010 to 1015 in health to 1020 and even to 1030. This is a rare form of disease, and according to Dr. Prout there are twenty cases of diabetes mellitus to one case of diabetes insipidus.

The *remote* and the *predisposing causes*, and likewise the pathology, as far as the facts of the disease are at present known, are exactly the same as in hydruria. The circumstance of the kidney being found healthy in this affection is explicable on the ground that the experiments of Prevost and Dumas have rendered it probable that urea exists formed in the blood, and that the office of the kidney is to separate it from that fluid. It will be seen, however, that urea being composed of oxygen, hydrogen, carbon, and azote, elements found abundantly in the blood, that it may be a secretion, and its excess a mere functional derangement of the kidney.

*Symptoms.*—There are supposed to be two forms of this disease, or diabetes insipidus with diuresis and without diuresis. In the latter case the urine is of the colour of porter, small in quantity and of great specific gravity. In the former the urine is pale, greatly increased in quantity, amounting often to eight, ten, sixteen, or more pints in the twenty-four hours, has an urinous odour and an acid re-action. The mode of determining the excess of urea is by pouring a small quantity of urine into a watch-glass and treating it with nitric acid. If the salt be in great excess, crystals of nitrate of urea will be seen at the edge of the fluid in a few hours. If, however, the quantity be smaller, it may be necessary to evaporate to about one-half before crystals will form. The crystals of the nitrate of urea are four-sided prisms, are neither acid nor alkaline, and are readily soluble in their own weight of cold water, and in any quantity of boiling water. Cold alcohol dissolves twenty per cent., and boiling alcohol any quantity of this substance.

The patient suffering from that form of the disease which is accompanied by great diuresis, is usually emaciated, hollow-eyed, sallow, and worn down by the great loss of azote. His bladder is also highly irritable, from the large quantity and morbid state of the urine with which it is so constantly distended; his bowels are likewise constipated, while his skin is harsh and dry, and without perspiration. On the contrary, when the diuresis is inconsiderable, he often preserves a considerable degree of *embonpoint*.

The duration of azoturia, if left to itself, is always long and tedious, pursuing an uninterrupted course of many months or years, and often when it subsides there is a metastasis to the lungs, and the patient dies of phthisis.

*Diagnosis.*—This disease can only be confounded with diabetes mellitus, and is readily distinguished if the party has the courage to taste, or the ingenuity to evaporate a small portion of his urine.

*Prognosis.*—The prognosis is always favourable, unless there be metastasis to the lungs, and then the patient usually falls.

*Treatment.*—No one definite plan of treatment can be laid down for this disease, but the milder forms are benefited by mild opiates, and the severer forms by opium and the mineral acids, as the infusi rosæ c. acidi sulphurici diluti ♏ v. c. tinct. opii ♏ iij. to ♏ x. 6tis vel 4tis horis; preparations of iron are also useful. Dr. Prout conceives calomel, black dose, and saline purgatives are calculated to do infinite mischief.

In hydruria, the diet should be generous and the quantity of animal food increased. On the contrary, in azoturia the quantity of animal food should be diminished.

## Diabetes Mellitus.

The peculiarity of this disease is that the urine is sweet, and actually contains sugar. Its quantity, also, is for the most part greatly increased, amounting to many quarts, while its specific gravity ranges from 1020° to 1050°, and even higher.

The saccharine quality of diabetic urine was first discovered by Willis, the contemporary of Sydenham, and the subject has since been chemically investigated by Cruikshanks, Rollo, Prout, Bostock, and many still more recent writers. Two hundred and fourteen cases of this disease are reported to have died in 1839 in England and Wales.

*Remote Causes.*—The remote causes of this disease are extremely obscure; it has been attributed to wet, to cold, and to excess in sexual pleasures, to malaria, to mercury; these, however, are insufficient, unless a strong idiopathic disposition exists.

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*Predisposing Causes.*—Diabetes mellitus has rarely been seen in persons under twenty. Both sexes are liable to it, but men are more commonly affected than woman; thus of those that fell from this disease in 1839, 151 were men, 68 women. The parties whom diabetes mellitus attacks are generally thin and emaciated, but occasionally full and plethoric. Dr. Prout mentions one gentleman that weighed twenty-three stone, and another who weighed seventeen stone. It has been observed in some instances to be hereditary, and in others to run in families. One German writer says he has seen seven cases in one family.

*Pathology.*—The kidneys in diabetes mellitus are often found healthy, but more commonly perhaps they are large, congested, and their vessels easily injected. In some few instances the kidneys have been found smaller or harder than usual, or to have undergone granular degeneration, or to have been beset with hydatids; but these forms of structural disorganization often exist without any tendency to diabetes, so that such conditions are altogether accidental. All pathologists therefore are agreed that diabetes mellitus is a disease of function.

Much speculation has been entertained whether the sugar contained in diabetic urine is formed by the kidneys, or is merely separated by them from the blood. Dr. Prout advocates the first opinion, and thinks the albumen of the blood is the radical from which not only urea and lithate of ammonia, but also sugar, are capable of being formed, and the following table will perhaps best show the foundation of this hypothesis:—

| Elements. | Albumen. | Urea. | Lithic Acid. | Sugar. |
|---|---|---|---|---|
| Hydrogen | 8·75 | 2·5 | 1·25 | 1·25 |
| Oxygen . | 30·00 | 10·0 | 15·00 | 10·00 |
| Carbon . | 56·25 | 7·5 | 22·50 | 7·50 |
| Nitrogen . | 17·05 | 17·5 | 17·50 | 0·00 |
| | 112·05 | 37·5 | 56·25 | 18·75 |

Whether the hypothesis of Dr. Prout be the true one is perhaps uncertain; but the formation of sugar by the kidney is rendered something more intelligible by the fact of the quantities of hydrogen and of oxygen in sugar being the same as those in water, and we have only, therefore, to account for the addition of the carbon, which exists abundantly in the blood, and the elements of sugar are palpable.

The hypothesis of sugar existing in the blood, and only separated by the kidney, has long been entertained; but even the delicate manipulations of Wollaston failed to detect it. Ambrosiani, of Milan, and Dr. Charles Maitland, however, are said to have obtained crystals of pure sugar from the blood, and also a larger portion of fermentable uncrystallizable syrup. More recently, Mr. Macgrigor, by coagulating and drying the albumen, then boiling it in water, and afterwards concentrating the decoction, obtained a syrupy fluid, which fermented for several hours with yeast; while Dr. Christison has even obtained sugar, but only in the proportion of one grain to eight ounces of blood.

The source of the sugar, according to Mr. Macgrigor, is the stomach, which generates it during digestion, when, in consequence of an imperfect chymification, it is afterwards taken up by the lacteals. In proof of this supposition, he states that he has repeatedly found sugar in the matters vomited after digestion had begun, and even in a case where nothing but animal food had been taken for a long time, and also that he has abundantly detected it in the fæces.

*Symptoms.*—The early symptoms of diabetes mellitus are obscure. Dr. Prout conceives there is a stage which precedes the formation of sugar, and which is marked by a superabundant and highly dense urine, loaded with an excess of urea. But much uncertainty prevails on this point, and nothing is assumed except that the constitution is not greatly affected till the saccharine matter forms. In some very few instances the quantity of urine passed is hardly greater than in health, but more commonly it is in great excess, amounting to eight, ten, sixteen, thirty, and even more pints, so that the patient is incessantly disturbed in the night, and loses his sleep, while the urethra and prepuce are inflamed and sore.

At this period his health begins to give way, his thirst is intense, and he often drinks many quarts, or even gallons, in the course of the day. But as the quantity drank is generally less than the quantity of urine passed, being in some instances only as one to four, his bowels are costive, and his fæces hard and dry; his appetite is capricious, his skin harsh and moistless, and he becomes greatly emaciated, loses all sexual desire, and it is said all sexual power. In advanced cases, the drain upon his constitution is so great that the alveolar processes are absorbed, and his teeth, loosened in their sockets, fall out. These symptoms are much relieved by medicine, and life much prolonged; but often, when the case appears most favourable, a latent phthisis, or other affection of the lung, breaks out, and he sinks under this unconquerable and intractable disease.

When the diuresis is considerable the urine should be examined, and its constituents determined; and the readiest solution of the problem is to taste it, and if it be sweet there can be no doubt of the nature of the disease. The chamber-vessel should also be examined, as also the flap of the patient's breeches, for crystals of sugar often form in the one as well as on the other. If we proceed chemically, a portion of urine, which is usually of a light straw colour, should be taken, and its specific gravity determined; and if greater than 1020° it should be evaporated, and if sugar be present we shall have a dark-brown residue, something like treacle. This extract, like the natural sugars, consists of crystallizable matter and of an uncrystallizable syrup; and to separate them Dr. Christison recommends that the extract be agitated with rectified spirit, and the residue boiled in another portion of the same fluid, when, on cooling, the crystallizable sugar will separate in light greyish grains like grape-sugar. Again, if sugar should be suspected to exist, but only in minute quantity, a small portion of yeast should be added to a small quantity of the urine, when, if sugar be present, fermentation will ensue, and each square inch of carbonic acid given off corresponds nearly to one grain of sugar. This test is so delicate that one part of diabetic urine, according to Dr. Christison, may be detected in 1000 parts of urine of the density of 1030.

Another method of determining the presence of sugar in the urine arises out of an experiment by Dr. Wollaston, who showed that when fluids of different densities are superposed one on the other, we have the phe-

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nomenon of double refraction. If a portion of diabetic urine, therefore, be left to stand for a few hours, the sugar will gravitate towards the bottom of the glass; and in this manner two fluids of different densities are formed, and the phenomenon of double refraction rendered apparent.

The density of diabetic urine, however, is one of the best tests. This fluid varies in density from 1020° to 1055°; and when the urinometer stands above 1030°, we may confidently affirm that sugar is present. The quantity of sugar present has been calculated by Dr. Henry at 1020° to be ʒvj. ℈ij. gr. ij. in every pint, while at 1050° it contains ℥j. ʒvij. ℈ij. grs. xviij. of sugar—the increment being, as he conceives, one scruple, or nearly so, for every degree of specific gravity between the extremes that have been mentioned. If these data be correct, a person passing 16 pints of urine daily, of specific gravity 1050°, actually passes nearly 2 lbs. avoirdupois of sugar.

As sugar is a non-azoted substance, it has been supposed that diabetes mellitus indicated a non-azoted diathesis of the kidney; and, consequently, that urea was always deficient in this disorder in proportion to the quantity of sugar secreted. It has been shown, however, by Henry, that although urea could not be detected by the ordinary methods of analysis, still that diabetic urine gave off carbonate of ammonia at a boiling temperature—a substance, he conceived, that could be derived from no other source than urea. At length Mr. Macgrigor, by first destroying the sugar by fermentation, and then concentrating the urine and treating it by alcohol, obtained in one case 43 parts of urea in 1000 of diabetic urine, or nearly 50 per cent. more than healthy urine contains; and Dr. Christison has obtained it in several instances by a similar process of fermentation, and then treating the urine with nitric acid.

The duration of this disease is very various; it always lasts many months, generally two or three years, and sometimes the patient has reached a moderately advanced age.

*Diagnosis.*—The sweet taste of the urine, the crystallization on the clothes of the patient, and the peculiar treacle-like syrup which remains after evaporating the urine, distinguishes this disease from all others.

*Prognosis.*—The ultimate issue of every case of diabetes is probably fatal; at least the number of cases in which the urine is rendered natural is extremely small, and many of them, at the moment the disease seems to have yielded, die of phthisis; even when the presence of the saccharine principle has been so far conquered that it alternates with lithic acid deposit, or that lithic acid becomes the prominent feature, the circumstance is anything but favourable, for I have noticed, says Dr. Prout, that such individuals generally die of some sudden and overwhelming attack of internal inflammation or of apoplexy.

*Treatment.*—There are few diseases in which the treatment has been more varied than in diabetes mellitus. The emaciated state of the patient would seem to present an insurmountable obstacle to bleeding; but, nevertheless, this mode of treatment has often been practised, and as much as 160 to 170 ounces of blood have been taken in a few weeks. Mercury has been used as an adjunct to bleeding, and separately; first as an alterative, then to touch the gums, and lastly to produce profuse salivation. But neither bleeding nor mercury, separately or conjointly, have been found of any benefit. Opium has been given to the extent of 100 grains in the 24 hours; but with an equal want of success. The whole materia medica has been exhausted in search of a remedy for this disease; and the metals, the fixed and volatile alkalies, the vegetable and mineral acids, all the astringents, purgatives, emetics, diaphoretics, diuretics, and tonics have in their turns been exhibited, and each has, perhaps, afforded some relief; but the disease has proceeded, and finally it may be said nearly every patient has fallen. Dr. Prout, who considers it merely as a form of dyspepsia, conceives that each case may require a different treatment.

The little benefit derived from medicine induced Dr. Rollo to try the effects of an entirely azoted or animal diet; and out of nineteen cases two are said to have been cured by this means. A full and generous diet is unquestionably useful in these cases; but the patient soon gets disgusted with mutton or beef, or both, for breakfast, dinner, and supper; he consequently nauseates it, and abandons it altogether. A diet of salt fish was attempted in one instance; but the patient in a short time so loathed it that it was given up. A mixed diet, therefore, if contra-indicated by theory, is at least the best to adopt in practice. It will be evident, however, that those vegetables which contain a large quantity of saccharine matter should be avoided in some degree, as potatoes, grapes, or other very ripe fruit, and, *à fortiori*, sugar itself.

### Of Urinary Deposits.

In the diseases of the functions of the kidney that have been mentioned, the urea, sugar, or other product has been held in solution. Two of the natural constituents of urine, however, as the phosphates and the lithates, although held in solution in that fluid in the proportions of health, yet being in excess become deposited, forming urinary sediments, and which, being precipitated in an amorphous state, are termed *sand*; in a crystallized state, *gravel*; and when concreted into masses, *stone* or *calculus*. Besides this excess of the natural constituents of the urine, there are also some other precipitable substances occasionally found in the urine, which are entirely new or morbid formations, as the oxalate of lime, and the xanthic and cystic oxydes, substances, although soluble, perhaps, in certain proportions in healthy urine, yet being in excess become deposited, and form urinary sediments, which for the most part concrete into calculi. The diseases produced by these different substances are termed Lithuria, Ceramuria, Oxaluria, Cystinuria, and Xanthuria. Our knowledge of urinary deposits, of whatever kind, is principally due to Scheele, Marcet, Wollaston, Yelloly, and Prout. The frequency of calcareous formations is not great, for 299 cases only are reported to have died of these diseases or of stone in England and Wales, in 1839.

*Lithuria*, or *Lithic*, or *Uric Acid Diathesis*, is that form of disease in which the lithates are secreted in such excess as to be deposited in inordinate quantities in the chamber-vessel on the urine cooling; or when in still greater abundance, deposited in an amorphous or crystallized state, either in the cavities of the kidneys or bladder. The specific gravity of this urine varies from 1015 to 1035, and always gives an acid re-action, and is of a deep copper or red colour.

*Remote Cause.*—Persons labouring under idiopathic uric acid diathesis are in other respects generally healthy,

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Elementary Principles of Medicine.

and the remote cause is for the most part referred to errors in diet, to sedentary or indolent habits, and, as this class of persons are for the most part nervous, to every atmospheric change. If we analyze the first of this series of causes we find that a too full animal diet, as rich old black meats and game, are among the most frequent. When the predisposition, however, to this diathesis is great, every substance, even the most opposite, that causes indigestion will produce it, as a heavy dumpling or new bread, the richer sort of fish or salted meats, acid fruits, or saccharine matters. Among wines, port is found too heavy, and claret and the lighter French wines too acid; while champagne, cider, and malt liquors are still worse, from the rapidity with which they ferment and turn acid.

Besides being the result of many errors in diet, a deposit of the lithates is incident to many diseases, as gout and rheumatism. It is also often a critical termination and first faint indication of recovery from fever, or severe form of inflammation. It is also imagined to result from morbid states of the liver. Besides denoting remote diseases, it sometimes results from an irritable state of the bladder, or from stone in the kidney or bladder.

*Predisposing Causes.*—The effects of diet are so marked in children, that we can hardly feel surprised that any error of diet, as overfeeding them, should be followed by lithic acid deposits. Stone cases are consequently common in children, and occur chiefly among those of the lower class, in whom those errors are likely to be most considerable. It is supposed that when stone forms in childhood that the ages most affected are between four and nine years. But of 506 children operated on at the Norwich Hospital, 223 were under 12 years of age, while 271 were between 14 and 15. Now two-thirds of all the cases of stone result from an uric acid diathesis. After these periods the ages of 40 and upwards present the greater number of cases of gravel, either because the frame now begins to break, or that increasing age enables us to enjoy the pleasures of the table, as well as to lead a more sedentary life. Majendie has assigned as a cause of these morbid states of urine in the extreme of life that the temperature of the body is from one to two degrees below the healthy standard of the adult.

Both sexes are liable to this affection; but taking stone cases as a test, men are infinitely more liable to uric acid deposits than women, for, according to Dr. Marcet, of 2216 cases operated on, only 88 were females. In many instances this disease appears to be hereditary, and the parties attacked are usually of sthenic constitution.

*Pathology.*—Lithic acid deposits not only occur when the patient is in his best health; but in many persons who have fallen labouring under this diathesis the kidney has been found healthy. Lithuria consequently arises from a mere derangement of the functions of the kidney. Indeed so purely is it a disease of function that the healthy kidney has been found occasionally studded all over with crystals of uric acid. Uric acid diathesis, however, may co-exist with most forms of disease of the kidneys, ureters, or bladder. It is by no means uncommon to find a calculus of this substance the nucleus of a mulberry or other calculus formed in the tubuli or pelvis of the kidney, and sometimes in the bladder.

Much difference of opinion prevails respecting the chemical nature and solubility of what is usually termed lithic acid. The analysis of Dr. Prout, however, on this subject is most generally received in this country. This eminent physician states that lithic acid may be precipitated in a crystalline form from urine that contains it by the addition of any mineral acid. The crystal is of a rhomboidal or cubic form, the latter being much the most rare, and is readily detected, on evaporation, by the microscope; it is white, tasteless, and inodorous, insoluble in alcohol, and very sparingly soluble in water, or requiring 10,000 times its weight of that fluid at 60° for solution. It reddens litmus paper; unites with alkalies, forming salts; and undergoes no change by exposure to air. On analysis it gives,

| | | |
|---|---|---|
| Carbon . . | 36 or 6 | equivalents. |
| Hydrogen . | 2 or 2 | ditto. |
| Oxygen . . | 24 or 3 | ditto. |
| Nitrogen . | 28 or 3 | ditto. |
| | 90 | |

These crystals, when treated with nitric acid, still form colourless crystals of a similar shape, and have an acid re-action, but what is remarkable is, that they form pink, red, or purple-coloured salts with an alkaline base, or different proportions of an alkali, and are hence termed by chemists purpuric acid, erythric and rosacic acids.

The different acids which have been described readily combine then with ammonia, with soda, or potash, and form with them super-lithates, lithates, and sub-lithates. The super-lithate of ammonia or the super-purpurate of ammonia are those, however, which are most generally found in urine. They give an acid re-action, and one part is soluble in 480 parts of water at 60°. In healthy urine they usually exist in the proportion of one part in 1000, which, taking the temperature of the body at 98, gives a three-fold excess of the solvent.

The colour of these salts varies greatly. The pure sub-lithate of ammonia is white; but, owing to the presence of the colouring matter in the urine, it is usually deposited of a yellow or wood colour. The purpurates, owing either to the nature of the colouring matter of the urine, or else to other circumstances not yet determined, are deposited of a pink, light red, or brick colour. These different salts may be deposited in a crystallized or in an amorphous state. The yellow amorphous sediments form calculi; but it is remarkable the red amorphous sediments in no instance are known to concrete into a calculus.

The lithic acid which exists in healthy urine in such a state and in such proportions as to be held in solution at ordinary temperatures, in certain conditions of the system may be precipitated from that secretion in a *crystallized* and nearly pure state, a specimen of which is now before us. In other states, or, according to Dr. Prout, when an febrile action exists in the system, the crystallized lithates are usually stained with the deeper tints of the yellow colouring matter of the urine, and are sometimes of a dark brown or red, so as to appear at first sight almost black. When, however, the patient labours under febrile action they are generally more or less of a red or lateritious colour; but in no instance has the same great authority seen crystallized lithates of a pink colour.

The *amorphous* and impalpable lithic acid sediments consist in general of lithic acid in combination with ammonia, and only in a very few instances with soda. The sedimentary deposits of the lithates of ammonia may be yellow, pink, or red; while the sedimentary



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deposits of the lithates of soda are white. The crystallized salts form gravel. The yellow amorphous sediments may concrete in the bladder or kidney, and form calculi.

In general the lithates and purpurates, whether in a crystalline form or as an amorphous sediment, even when in great excess, are held in solution at the temperature of the body; but in some instances their superabundance is so great that they are deposited, even at this temperature, either within the bladder or kidney, so that the last portions of urine are so loaded with them as to resemble a stream of blood. If the excess be yet greater, or if a nucleus be present, a concretion may form either in the kidney or bladder, but infinitely more commonly in the former. The nucleus may be either a piece of hardened mucus, or a portion of fibrine or other substance, or it may be a crystal of lithic acid. The formation of crystals of lithic acid has been variously accounted for. Dr. Prout thinks they may be deposited in the kidney as a gelatinous hydrate; or that they may be precipitated by the presence of nitric acid depriving the acid of its base; or that a portion of thickened mucus may afford a nucleus on which they may shoot and crystallize. In whatever manner, however, the nucleus may be formed, or of whatever substance, around this nucleus the amorphous sediments are gradually deposited. The calculi thus formed are of very different sizes, sometimes so minute as to be not bigger than a pin's head; but if longer retained they acquire a magnitude from a walnut to a goose's egg.

Calculi of pure lithate of ammonia are so rare that their existence has been denied; but they have been met with in infants and children. Lithic acid calculi are, therefore, generally lithate of ammonia mixed with many impurities, and are hard, of a light clay, fawn, or wood colour, for the most part smooth at the surface; and the concretion, when sawn in two, is found to be composed of concentric layers, like an onion. The simplest test of this form of calculus is nitric acid, which readily dissolves it, and on evaporation yields purpurate of ammonia.

The lithates, however, are very frequently only the nucleus of a calculus of different formation, as the phosphates or oxalates. Indeed we not unfrequently see the lithates, the phosphates, and the oxalates deposited in alternate layers in the same calculus, thus affording absolute demonstration of three or four different diatheses having prevailed during the formation of the same calculus.

*Symptoms.*—The fact of lithic acid being in excess is palpable enough, from the yellow, red, or pink deposit in the chamber-vessel as the urine cools; and when this is moderate in quantity the patient, perhaps, suffers neither local nor general inconvenience; indeed many persons are never better than when they are passing an excess of the lithates. When, however, it is deposited as an amorphous sediment in the bladder, the last portions of urine are so loaded with it, that the patient apprehends he is passing blood. In this case, in the first instance, he is only troubled with itching and pain in the urethra in making water; but if the disease becomes chronic the bladder becomes irritable, the urine loaded with mucus, the healthy sympathy between the bladder and prostate is destroyed, so that the urine is only passed after great forcing, and in trifling quantity, and his sufferings are singularly painful and severe. The secretion of a great excess of the lithates is seldom a purely local disease, but is usually vicarious of, or accompanied by, some more general affection, as cardialgia, asthma, palpitation of the heart, rheumatism, or gout; and during its continuance these diseases often, in a great measure, subside.

Although the passage of an amorphous sediment, unless it be in such quantity as absolutely to obstruct the passage, is seldom productive of much local inconvenience, unless it be of long continuance; yet when the lithic acid crystallizes so as to form gravel, or a still larger concretion, the expulsion of this foreign body is always attended with much pain, and gives rise to what has been termed nephritic colic.

*Colica Nephritica.*—The passage of a calculus from the kidney into the bladder may be preceded by dull pains in the back and some sickness; but more commonly the attack is sudden, and the patient, perhaps, in his best health, and engaged in the ordinary transactions of life, is on the instant seized with excruciating agony in the loins, with retraction of the testicle, irritation of the bladder, and often with nausea and vomiting; but in all this suffering the pulse retains its healthy frequency, and the heat of the body is natural. At length the pain intermits, and the patient has a short interval of ease. The paroxysm, however, returns more or less frequently, till the patient is relieved as by a charm, the calculus having passed into the bladder. Again, after an uncertain interval, the gravel or calculus becomes impacted in the neck of the bladder, when the same phenomena present themselves, but have a different locality, or the urethra, till at last, after an effort to pass water, the noise of a stone falling into the chamber-vessel is heard, and the gravel or calculus is found.

The duration of this fit is very various, lasting perhaps from one hour to many, and sometimes continuing for many days. Occasionally, however, the calculus has acquired so great a magnitude that it becomes impacted in the ureters and death has ensued from this cause. In general, calculi pass from one kidney only at a time, but sometimes they pass simultaneously from both kidneys; and should they be large, or the passage long, an entire suppression of urine has been the consequence, and the patient has fallen from that cause.

Sometimes the calculus so rapidly increases by sedimentary deposits that it is detained altogether in the kidney, when it not only takes the form of the pelvis of the kidney, but branches out in every direction like a piece of ginger. In a few instances, a calculus thus formed in the kidney may lie latent and cause little inconvenience to the patient, as in the case of the daughter of Sir Richard Steele, who was found to have one of these large calculi in the kidney, although she had made no complaint referable to that organ during life. More commonly, however, the calculus acts as a foreign body, and the kidney becomes the seat of abscess or other disorganization, and the patient suffers immensely with pains in the back, irritability of the bladder, aggravated by the frequent discharge of pus, of blood, or mucus. Existence under these circumstances becomes a burthen; and death, long prayed for, at length terminates the patient's ceaseless sufferings.

A calculus having passed into the bladder sometimes increases so fast that it acquires a magnitude too great to escape by the urethra, and in this case a stone in the bladder is formed; and this disease, as it necessarily requires an operation, will be found treated of under the head of surgery.

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*Diagnosis.*—The red lithates can alone be confounded with blood, and from which, when intense in colour, they often can with difficulty be distinguished. On cooling, however, the subsidence of an impalpable or gritty deposit, the presence generally of much mucus, the absence of fibrine, and also of albumen, when the urine is treated by nitric acid, enable us readily to distinguish them. The white or light-coloured lithates are distinguished from the phosphates by the urine being acid, by the absence of the abundant mucous discharge which always accompanies a large deposition of the phosphates, and from the urine not becoming alkaline or fœtid if kept for a few hours. The precipitated lithates also are readily dissolvable by heat, which the phosphates are not.

*Prognosis.*—While the deposits are yet but sedimentary, the prognosis is always favourable, however large the quantity discharged. Even when gravel or small calculi are formed, the chances are very many that it will be discharged before it attains any considerable size. When the calculus is so large, however, as to be retained in the kidney or ureter, the disease is necessarily fatal. Also, when retained in the bladder, nothing but a surgical operation can remove it; and consequently the chances resolve themselves into the proportionate numbers which recover or fall after the operation of lithotrity or lithotomy at the age and under the circumstances of the patient.

*Treatment.*—The medical treatment of the lithic acid diathesis is extremely well determined, or by alkalies or neutral salts, turpentine, and saccharine matters.

The celebrated Morgagni suffered greatly from lithic acid gravel, and his remedy was, half a drachm of carbonate of potash night and morning, gradually increasing the dose till he took three drachms during the day. "The acid of his urine," he states, "soon became saturated, the pain in his loins diminished, his urine became less loaded, and potash was at length found in that fluid in excess." He also adds, "I have repeated this remedy as often as I have been threatened with an attack, and always with success." The particular salt, however, is not perhaps of great moment, for Sir Gilbert Blane found his patients much benefited by the citrate of potash, or the common effervescing draught. When the patient's bowels require a more active agent, the sulphate of magnesia, the sulphate of soda, or the iodide or bromide of potash may be substituted.

The pure alkalies, from the much smaller doses in which they can only be administered, are much less beneficial than the neutral salts. Magnesia, also, in Mr. Brande's experiments, produced much less marked effects on the urine than either the subcarbonate of potash or soda, while lime-water produced no very sensible effect whatever.

Besides alkalies, turpentine has some character in the core of the lithic acid diathesis. The celebrated Dutch drops are supposed to be principally composed of sp. terebinthinæ and of tinct. opii, coloured by petroleum. Dr. Henry gives two cases of the beneficial effects of this remedy. One of them was a lady, who, when threatened with an attack, always had recourse to it, and the uniform effect was the discharge of a sandy substance in such quantities that often four ounces were discharged in two or three days. The other instance is of a similar description.

The above-mentioned treatment is often successful; but there are cases in which it fails, and the patient continues to be tormented for months with little relief. In these instances, the inf. diosmæ or the pulv. uva ursi may be tried, combined with some mild opiate, which latter substance always gives relief.

If the urinary sediment should concrete into gravel, an attack of nephritic colic may take place. The treatment of this attack is the same as for the passage of a gall-stone; or the warm bath, mild purgatives, and opiates. The inexperienced practitioner should be cautioned against the use of blisters lest the absorption of the peculiar principle of the lyttæ should occasion strangury.

If the calculus, having escaped from the kidney, is retained in the bladder, an operation for its removal is necessary, and the case now becomes purely surgical.

*Dietetic Treatment.*—The dietetic treatment is of the greatest importance in the cure of the lithic acid diathesis. The experiments of Wollaston and Vauquelin have shown that in proportion as animals are fed on animal diet or on azoted substances, their urine becomes more and more loaded with lithic acid. While Majendie has shown by a counterproof, if a dog be fed on non-azoted substances, as sugar, every trace of lithic acid disappears from the urine. A lady at Paris, suffering from gravel, having heard of Majendie's experiments, made trial of sugar on herself, eating more than a pound daily. She persevered in this regimen for six weeks, when her gravel disappeared. She now returned to her old regimen, and at the end of three months her fits of gravel returned.

It is plain, therefore, that the quantity of animal food should be reduced. It is necessary also that port as well as French wines should be abandoned, as well as all those things which, according to the idiosyncrasy of the patient, are likely to produce indigestion or acidity of the stomach. The patient also should be warmly clad, rise early, and take a considerable portion of exercise.

*Ceramuria or Phosphatic Diathesis.*—The phosphates are secreted in a state of health in the proportion of one part in 1000 of urine. When this proportion is abnormally increased, so that they are largely deposited either in the kidney or bladder, or even in the chamber-vessel, they produce the disease termed the phosphatic diathesis.

*Remote Cause.*—The remote causes of this affection are exposure to cold and wet, poor diet, blows on the back, and more especially diseases of the bladder, as vesical catarrh, stone in the bladder, the introduction of a bougie, or other irritating cause.

*Predisposing Cause.*—This form of disease sometimes occurs in children, but more commonly in adults between thirty and forty years of age. It affects both sexes, but more commonly the male than the female. The party affected is usually of an asthenic, pale, leucophlegmatic temperament, and in most instances is supposed to have inherited it.

*Pathology.*—This affection, though often resulting from disease of the bladder or kidney, yet occasionally exists when no such disease is present, and consequently is essentially a disease of function. It is the prevalence of this diathesis that causes those large calculi sometimes found in the kidney or bladder.

The elements of this diathesis exist in the blood; for the red particles, the albumen and fibrine, when burnt, all yield a small portion of the earthy phosphates. Berzelius is of opinion that, previous to incineration, they exist in the blood in the states of phosphorus, of calcium, of magnesium, of sodium, and of potassium



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Elementary Principles of Medicine.

the office of the kidney being to acidify the phosphorus and combine the phosphoric acid with these different bases, according to their affinities and quantities. In healthy urine these salts exist in the state of the biphosphates, and in the proportion of one part in 1000. So that, supposing one part of these salts to be soluble in 480 parts of urine at 60°, the solvent at 98° is about two-thirds in excess. These salts, like the super-lithates, have the property of reddening vegetable blues, and they show an acid re-action. When the earthy bases of lime or magnesia are from any cause secreted in greater abundance than natural, they combine with the biphosphates, which are now thrown down in the form of insoluble phosphates, and which may be deposited either as a sediment on the urine cooling, or in the bladder or kidney before being passed, or else being retained in those cavities may concrete into a stone or calculus.

*Symptoms.*—When this diathesis is a primary affection, the party is usually of a sallow complexion, stout, but effeminate, and of great irritability of nerve. He also suffers from indigestion, flatulence, constipated or disordered bowels, his stools being either black or clay-coloured. His bladder also is highly irritable; he has a pain in his back and loins; his urine is abundant and loaded with mucus, together with a copious white sediment, so that the latter portions of urine pass like so much milk.

The duration of this disease is often very chronic, on account of the diseased state of the bladder, with which it is connected. In cases, however, in which that viscus is healthy, it often readily yields to medical treatment; but in other instances, when all appears to be proceeding favourably, the lungs become affected and the patient dies of phthisis.

The urine, when examined, is pale, increased in quantity, often turbid, and covered with an iridescent pellicle or film, consisting of a solution of the triple phosphate of ammonia and magnesia; much mucus is also deposited, together with a most copious precipitate of the phosphates, so that sometimes the urine appears like so much chalk and water. It is singular, however, that although the urine is so loaded with foreign matters, it is generally of low specific gravity, or 1001, 1002, or 1003.

As the phosphates have little tendency to crystallize, a nucleus is necessary before the sediment can concrete into calculi; and it is in this form of disease that we find such singular substances in their centres, as a clot of blood, a piece of hardened mucus, broken ends of sounds or bougies, bits of straw, bodkins, pins, plum-stones, beans, nut-shells, and bullets.

The calculi which form on these nuclei are of three descriptions and in the following proportions. Out of 102 calculi examined there were of—

| | |
|---|---|
| Phosphate of lime, nearly pure | 8 |
| Triple phosphate, or phosphate of ammonia and magnesia | 3 |
| Mixed or fusible calculi, being a mixture of the two preceding | 91 |
| | 102 |

These calculi are distinguished from all other calculi in being soluble in an excess of phosphoric acid. They are distinguished from one another by the phosphate of lime calculus being nearly infusible, by the mixed being readily fusible, while the triple phosphate is known by the minute crystals which often form between the interstices of the laminæ.

Every other form of calculus, whether the lithate or the oxalate, from the irritation it occasions, constantly produces a deposit of a soft coating of the phosphates. When, however, the phosphatic deposition is once well established, it is seldom followed by the deposition of strata of any other description. Thus of 823 calculi examined by Dr. Prout, he found only three specimens in which the phosphates had been followed or surrounded by other calculous deposits; and hence he deduces the important law, that a decided deposition of the phosphates is not followed by one of any other description.

The physical characters of the phosphatic calculi are, that they are white, soft, and easily broken down, and are deposited in concentric laminæ like the lithic acid concretions.

*Diagnosis.*—The phosphatic sediments may be distinguished from the lithic by the urine, though at first acid, becoming putrescent, and giving an alkaline reaction after standing a few hours. Ammonia also added to the urine throws down a white cloud, which consists of the phosphate of lime with some of the ammoniaco-magnesian phosphates, a test which would render the lithates soluble. The best test, however, is the addition of phosphoric acid, which would re-dissolve the precipitate.

*Prognosis.*—When this diathesis is unaccompanied by disease of the bladder the prognosis is always favourable. When, however, it results from a morbid state of the bladder or diseased structure of the kidney, the disease is always of long duration. Should metastasis take place to the lungs the disease is fatal.

*Treatment.*—The treatment of this affection is by some mineral acid combined with an opiate. The acid is not very important: and the nitric, muriatic, the phosphatic, or the sulphuric are equally beneficial; but the dilute sulphuric acid is generally preferred as being most pleasant to the taste. The most usual remedy therefore is the infusi rosæ, with an addition of ♏v. to ♏x. of dilute sulphuric acid, together with tinct. opii ♏iij. to ♏v. every six hours. This combination is generally so powerful in checking this affection, that the sulphate of magnesia may be added to it if the bowels should require to be regulated.

When the phosphatic diathesis depends on vesical catarrh, or other diseased state of the bladder, salicinæ gr. x. ter die has occasionally been found successful. Others prefer the inf. diosmæ, and others uva ursi. It is decidedly bad practice to use the pure alkalies in these cases.

*Dietetic Treatment.*—The diet should be as nourishing as the state of the diseased viscus will allow; and acid, wines, and ripe fruits greatly assist in effecting the cure.

*Oxaluria.*—Is that diseased function of the kidney by which oxalate of lime is secreted, a fact first determined by Dr. Wollaston.

*Remote Cause.*—The remote cause of this disease is not determined, for persons in the best health will often void an oxalate of lime calculus. It is supposed, however, to be most frequent among those who eat largely of common sorrel (rumex acetosa), or of tomata (solanum lycopersicum), and of the leaf-stalk of the rhubarb plant, all of which many persons are passionately fond, and all of which contain oxalic acid.

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Elementary Principles of Medicine.

*Predisposing Causes.*—This form of disease may exist before puberty, and from that period till sixty, beyond which age Dr. Prout has met with no case. It is most usual, however, between forty and fifty. It attacks both sexes, and is not incompatible with gout.

*Pathology.*—This disease is decidedly a disease of function, and not connected with any known alteration of the structure of the kidney.

Oxalic acid being composed of carbon 33·99, and of oxygen 53·33, the elements of this acid exist abundantly in the blood, and probably in many instances this formation takes place entirely from a vitiated action of the kidney. The experiments of Woehler, however, have, he thinks, proved beyond a doubt that the oxalic is one of the few acids that make their way into the torrent of the circulation, and are eliminated, both free and combined with a base, from the kidney. He caused a dog to swallow two drachms of oxalic acid mixed with a quantity of bread and meat, and on examining the urine it was found to deposit a precipitate on cooling, and a further precipitate on the addition of nitrate of lime. On both precipitates being collected, they were found to consist of oxalate of lime, almost demonstrating that the oxalic acid must have been carried directly from the stomach to the kidney.

The oxalate of lime very rarely appears under the form of an amorphous sediment; still it has occurred mixed with the lithic amorphous sediments, but even this is uncommon. Its appearance is still more rare under the form of crystallized gravel, so much so that Dr. Prout mentions only two instances. Renal calculi of this formation are not very uncommon, since Dr. Prout mentions having met with twelve cases. When detained in the bladder they often acquire a considerable size, are rugged, dark-coloured, and tuberculated, and from these appearances have been termed the "mulberry calculi." Oxalate of lime enters as a constituent part into about one-fourth of all the calculi examined. The following table will show the different transitions:—

| | |
|---|---|
| Oxalate of lime | 113 |
| Lithic and mulberry | 15 |
| Mulberry and lithic | 40 |
| Mulberry and phosphates | 49 |
| Fusible and mulberry | 2 |
| | 219 |

When heated before the blow-pipe the oxalic acid is decomposed, and pure lime remains, which gives a strong brown stain to moistened turmeric paper. This calculus is insoluble in the alkalies, but by digestion in carbonate of potash it is decomposed, and the insoluble carbonate of lime is left. When reduced to powder and digested in nitric or muriatic acids a perfect solution is effected. It is not dissolved by acetic acid—a circumstance which distinguishes it from the ammoniaco-magnesian phosphate. It is distinguished from the phosphate of lime by being insoluble in phosphoric acid.

*Symptoms.*—This disease is attended with no prominent feature. The urine, which contains this substance, is acid, of a good colour and remarkably pure, and free from all sorts of sediment as well as gravel. The patient is therefore hardly sensible of any inconvenience till he is attacked by a fit of nephritic colic, caused by the passage of the calculus from the kidney or bladder, or else till he is troubled, supposing it to be retained, by symptoms of stone in the bladder or kidney.

*Diagnosis.*—The mode in which this calculus may be distinguished from all others has been already described.

*Prognosis.*—It is seldom that a second calculus of the oxalate of lime exists in the kidney after one has been passed. When it is detained in the bladder the patient is of course submitted to the accidents of a surgical operation.

*Treatment.*—Very little is known respecting the medical treatment of this calculus. Dr. Prout recommends, after passing a mulberry calculus, that we should induce a lithic acid diathesis; but it must be questionable whether the disease substituted is not as dangerous as the one under which the patient originally laboured. He speaks, however, of having seen much advantage derived from mineral acids and the sulphates of iron or of quina. The fixed alkalies often do absolute mischief.

*Dietetic Treatment.*—The patient should carefully avoid eating all substances containing oxalic acid. A gentleman who had lived as a *bon-vivant*, determined to reform his diet, but to render his new dishes more palatable, he ate every day a plateful of sorrel, and was attacked with an oxalate of lime calculus.

*Cystinuria.*—The cystic oxyde was described by its discoverer, Dr. Wollaston, in the 'Philosophical Transactions for 1810;' and from the similarity which this substance bears to certain oxydes in uniting both with alkalies and acids, Dr. Wollaston termed it an oxyde, and gave it the name of cystic oxyde, on the supposition of its being peculiar to the bladder. Dr. Marcet, however, has found it in the kidney. This substance has only in a few instances been discovered, but is suspected by Dr. Prout not to be infrequent.

*Remote Cause.*—The remote cause of this disease is entirely unknown.

*Predisposing Causes.*—The first calculus examined by Dr. Wollaston of this description was taken from a boy five years old. It has been found also in the adult; and Professor Stromeyer found it in two instances in one family, and it is supposed also to be hereditary.

*Pathology.*—The cystic oxyde diathesis is probably a disease of function, but in most of the instances examined at present, the kidneys have been found diseased. An analysis of this concretion by Lassaigne gives—

| | |
|---|---|
| Carbon | 36·2 |
| Hydrogen | 12·8 |
| Oxygen | 17 |
| Nitrogen | 34 |
| | 100 |

The elements of cystic oxyde, therefore, exist plentifully in the blood. This substance appears to result from an original diathesis, and has been discovered in the urine in a state of solution, of mechanical suspension, and also in the solid form of a calculus, either pure or else incrusted with the phosphates or lithates. The concretion, when pure, is not laminated, but appears as one uniform mass confusedly crystallized through its whole substance, having somewhat of the appearance of the ammoniaco-magnesian phosphate, though more compact. Before the blow-pipe it emits a peculiarly fœtid smell, quite distinct from that of uric acid, and is consumed. It is characterized by the great variety of re-agents in which it is soluble. It is dissolved abundantly by the muriatic, nitric, sulphuric, and oxalic acids; by potash, soda, and ammonia, and even by the neutral carbonates of soda and potash. It is insoluble in water, alcohol, bicarbonate of

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ammonia, and in the tartaric, citric, and acetic acids. The urine in which this substance has been found was copious, of a yellowish green, of a strong peculiar smell, and of a low specific gravity, or 101148; it was entirely free from uric acid, and the urea deficient in quantity. This diathesis is of unfavourable prognosis, and its mode of treatment not yet determined.

*Xanthuria* is only known by the occasional existence of an exceedingly rare calculus, first discovered by Dr. Marcet, and has since been met with by Liebig and Woehler, and also by Professor Langenbeck, of Gottingen. Its chemical characters are hardly determined, but it turns yellow when treated with nitric acid, and it is supposed to be formed of the same elements and in the same proportions as lithic acid, only minus one atom of oxygen. The causes of this disease, as well as its treatment, are at present very obscure.

Dr. Marcet has also described a variety of calculus under the name of *fibrinous* calculus, which appears to be composed of the fibrine of the blood. Sir Benjamin Brodie has met with one specimen of this formation. It was of an oval shape, about the size of a horse-bean, yellow, semitransparent, not very unlike amber in appearance, but less hard. When dry it shrivelled up. Dr. Hodgkin found in the bladder of a boy after death a concretion which consisted of concentric layers of a white elastic substance, like coagulated albumen, and between each layer was a thin strata of very friable earthy matter, probably phosphate of lime. Nothing further is known of this unusual disease.

### Of the Diseases of Function of the Uterus.

The functional diseases of the uterus are leucorrhœa, amenorrhœa, and its variety, chlorosis, and also dysmenorrhœa. This class of disease has been known since medicine was a science.

### Of Leucorrhœa.

Leucorrhœa is a white or nearly white discharge from the vagina, unattended with pain.

*Remote Cause.*—This affection may arise from all those moral or physical causes which depress the system generally, and which act so powerfully on the frames of delicate females, as any severe mental suffering, the depression which follows high excitement, exhaustion caused by hot rooms, sudden or great changes of temperature, deficient nourishment, or, on the contrary, too stimulating a diet. Leucorrhœa, likewise, has many local causes, as the irritation and weakness caused by abortion or child-bearing, and in the latter case it often continues during the period of suckling.

*Predisposing Causes.*—Leucorrhœa is occasionally seen in young children, but is only common to adult age. It may attack women at all periods of life, but is most frequent from sixteen to twenty-five. It is a disease to which females of every temperament are subject; for, of nineteen cases given by Marc d'Espine, six were robust, nine moderately strong, and four only were sickly.

It is not uncommon to find the "whites" in young females occurring monthly, for a short time preceding the development of the catamenia, and for a few months after their appearance. At a later period of life a similar discharge often takes place at regular times in women labouring under amenorrhœa, and often continues until the natural secretion is restored. Leucorrhœa is also common in many women during the intervals of menstruation; and in these cases the discharge may increase for two or three days previous to the appearance of the menses, cease during their flow, but reappear after their subsidence. In other cases leucorrhœa alternates with menorrhagia.

*Pathology.*—The leucorrhœal discharge may proceed from the uterus, the vagina, or from both; but the structure of these parts, with very few exceptions, is perfectly healthy. Marc d'Espine* has shown this to be the case by a number of examinations made by the speculum; for he found the orifice of the uterus perfectly healthy in fifty-three cases, slightly red in thirty-five cases, and red and granulated in twenty-five cases. This disease is therefore strictly a disease of function. It has been asked whether this discharge is secreted by the mucous follicles, or by the web of the mucous membrane, supposing the uterus to possess one; and it seems most probable both systems are faulty in this affection. The pain under the left breast, which so often accompanies leucorrhœa, cannot be accounted for by any structural lesion, neither by any direct nervous sympathy. Valleix conceives it to be a dorso-costal neuralgia, but is unable to explain its occurrence as a symptom of this affection.

*Symptoms.*—The leucorrhœal discharge is usually of a bland muciform nature, and probably contains some albumen. Its quantity is often so considerable as to wet several napkins in the twenty-four hours; its consistency is various, or from a transparent and almost aqueous discharge to one of considerable thickness and opacity, while its colour differs from nearly a pure white to a blue or yellow.

The patient is not sensible of any increase of local heat, pain, or tenderness in the part from which the discharge proceeds; but her constitution is generally languid and weak, her complexion pale and sallow, and often with a dark areola under her eye. She complains of pain in her back, but the more characteristic symptom is a pain on the left side, sometimes on the right, and occasionally on both sides, and which is often constant, severe, and distressing. The tongue is generally clean, the pulse quick and irritable, and the bowels constipated. In a few cases the constitution sympathises more actively, and in these instances syncope, hysteria, and perhaps some local irritation, as bearing down, is present.

The duration of leucorrhœa is very various, but it seldom lasts longer than from two weeks to two months under medical treatment; but if left to itself, it is often many months in subsiding.

*Diagnosis.*—Leucorrhœa is distinguished from gonorrhœa by the moral character of the party, by the absence of all local pain, by the whiteness of the discharge, and by the pain in the side, which is often mistaken for pleurisy or for hepatitis, and the patient is sadly punished in consequence. In nineteen cases out of twenty, however, the existence of the leucorrhœa is sufficient to determine the harmless nature of the pain.

*Prognosis.*—The prognosis is in every instance most favourable.

*Treatment.*—The treatment may be general or local, or both conjoined. A large number of cases readily yield to a general treatment by the mineral acids. The infusi rosæ ℥ xj. sp. ætheris nitrici ʒ j., to which may be added magnesiæ sulphatis ʒ j. should the bowels be costive, and also tinct. hyoscyami ♏ xv. if there should be pain in the side, ter die, is a prescription very often

* *Archives Générales.* February, 1836.

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successful. In the more obstinate cases the draught may be strengthened by ℞iij. to ℞v. of dilute sulphuric acid. If the patient at the same time be labouring under amenorrhœa, one to three grains of the sulphate of iron may be substituted for the æther; or, what is still better, ten grains of salicine three times a day. The cold bath, horse exercise, and country air are desirable adjuvants.

When the disease has resisted general remedies, some local treatment is necessary, and this consists of astringent injections thrown up the vagina by a syringe or Indian-rubber bottle. The most popular injections are the decoctum querci, or a drachm of alum dissolved in four ounces of water, or else a drachm of the sulphate of zinc to the same quantity of water, or ten to twenty grains of the nitrate of silver in the same quantity of distilled water. These injections should be administered slowly, the patient being in a recumbent posture. They seldom give any pain. Some difference of opinion exists as to the form of disease in which they are useful, for some practitioners rely almost entirely on them for the cure of vaginal leucorrhœa, but consider them as highly injurious when the discharge takes place from the uterus; while others use them in every case.

In very acute forms of leucorrhœa cupping from the loins, or leeches to the lower portion of the abdomen, are useful, and after this hip-baths and vaginal injections of warm water may be employed till the severity of the attack has subsided.

*Dietetic treatment.*—The diet in most cases of leucorrhœa should be light and nutritious, and a glass or two of some French or Rhenish wine greatly assists the patient's recovery.

### Of Amenorrhœa.

Amenorrhœa is a partial or total suppression of the menstrual discharge at the usual periods.

*Remote Cause.*—Amenorrhœa arises, like leucorrhœa, in some women from great delicacy of constitution; in others from the luxurious routine of a London life. There are likewise many other more direct causes, as taking cold during the term of menstruation, and especially by getting wet in the feet. Any powerful mental or physical shock received during the same period is also a cause. Amenorrhœa is also a consequence of most severe disorders, as fever or phthisis.

*Predisposing Causes.*—It is difficult to say at what age, taking the extremes of adult life, a party may be said to labour under amenorrhœa, for great differences exist as to the time of commencement of the first menstruation and the termination of the last.

It may be stated, however, that the most general age of puberty in the female is about fifteen, and also that rather before fifty this sexual function ceases. Amenorrhœa is perhaps most common at these two extremes of adult age. In young women, for example, the first appearance of menstruation is often followed by an intermission of two, three, or more periods, after which this function is regularly performed unless some disturbing cause suppresses it. The middle periods of life are in most women occupied between pregnancy and suckling, so that a considerable portion of life is thus passed in a state of natural amenorrhœa. Towards the close of the menstrual period, however, the functions of the uterus are more feebly performed, and during the last three or four years menstruation often intermits, returns, and then ceases altogether.

*Pathology.*—In amenorrhœa the uterus retains its healthy structure. The only sensible difference is that the cervix is perhaps smaller and more pointed, but at the proper periods even this enlarges and assumes the natural and healthy form incident to that time. Amenorrhœa is consequently a result of mere disordered function of the uterus.

Amenorrhœa, besides being a mere functional disease, sometimes arises from congenital malformation; thus the uterus may be wanting, or it may be irregularly or incompletely developed. The canal in the cervix may be imperforate; there may be a membrane covering the os uteri; the vagina may be wanting, its sides adherent, or its orifice closed by adhesion, a false membrane, or an imperforate hymen. The ovaries also have, in some instances, been found wanting; nevertheless the persons in whom this defect occurs are in other respects well formed and healthy, and all the organic functions, save the one in question, fully performed. The bosom, however, of such women is not prominent, their voice is deeper than is usual, and a slight beard appears on the upper lip, so that there is a mixture of masculine and feminine peculiarities both of person and character in these individuals.

*Symptoms.*—Amenorrhœa may be partial or total, that is, the menses may be deficient in quantity or be delayed as to time, or may be altogether suppressed for one or more periods.

When amenorrhœa is partial the quantity may be smaller than usual. Thus the mean quantity lost amounts to about four ounces; but it may now be reduced to a mere show, and hardly soil more than one or two napkins. It may also be defective as to quality, being often much paler than usual. Again, amenorrhœa may be partial as to time, the menses appearing only every five or six weeks instead of every month. Again, the amenorrhœa may be total, the discharge not taking place perhaps till after the lapse of one, two, or more periods. Whichever form amenorrhœa may assume, the symptoms are nearly the same, and are usually divided into acute and chronic.

Acute amenorrhœa generally takes place from some cause acting immediately previous to or during the menstrual period, such as exposure to cold or wet, anxiety, fright, or an attack of fever or other severe disorder. In this case there is considerable febrile action, flushed face, a quick pulse, great pain in the back and side, and often much local suffering; while instances are known in highly excitable females of this apparently trifling affection terminating in insanity.

Chronic amenorrhœa is generally the result of much constitutional debility, and the patient at the usual mensual period has shivering; pain in the back and loins, and down the thighs; weight at the lower part of the abdomen, together with great lassitude and depression. These symptoms, having lasted a day or two, pass away without any menstrual secretion, and are repeated each succeeding month till there is a return to a healthy state. But the effects of this abortion are not so temporary, for in the intervals severe headache, throbbing, and a sense of fulness in the temples and pain in the left side are for the most part present. The appetite also is impaired, the bowels irregular, the countenance pale, the strength much reduced, together with paroxysms of hysteria or of palpitation.

The most exquisite form of chronic amenorrhœa, however, is *chlorosis*, or the *green* sickness. In this

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ease, in addition to the previous symptoms, the countenance is singularly sallow, or of a yellowish green, and bloated, and the legs œdematous, with in general much arterial action, producing in the carotids the "bruit du diable." In many of these cases also the appetite becomes singularly morbid and depraved, while the patient's strength and spirits are depressed in the extreme; she is readily overcome, and bursts into tears on the slightest emotion, and generally passes much time in her room.

Amenorrhœa is sometimes accompanied by a vicarious hæmorrhage from some remote organ, and generally from the stomach, lungs, or nostrils; but cases are recorded in which it has burst forth from the eyes, ears, gums, arms, bladder, nipples, the ends of the fingers and toes, from the joints, the axilla, the stump of an amputated limb, from ulcers, varicose tumors, and from the surface of the skin generally. The attack in these cases comes on suddenly, and continues at intervals for some days, unless the quantity be very great, in which case there is only one hæmorrhage. The local and perhaps constitutional distress under which the patient laboured may have been thus relieved, but her health is not re-established in the interval. Vicarious hæmorrhage, instead of occurring every month, sometimes alternates monthly with the catamenia, and sometimes again it only occurs after long periods, so as to appear quite accidental.

Instead of vicarious hæmorrhage, it sometimes happens, when the patient's health has suffered greatly, that the leucorrhœal discharge has appeared at the regular periods, instead of the menses, and this for many successive periods, greatly adding to the nervous sensibility which so remarkably characterizes this disease, and giving rise to the most exquisite forms of hysteria.

*Diagnosis.*—The points involved in the diagnosis are, whether the amenorrhœa is the result of pregnancy, or of congenital malformation, and these cases can be readily determined by an examination. It should be remembered that there are endless instances of a woman bearing many children successively without menstruating, the impregnation taking place during lactation. Professor Frank also gives the case of a woman who bore three children, without having menstruated either previously to her marriage or subsequently to the birth of the children.

*Prognosis.*—Amenorrhœa is itself void of danger, unless it denotes the existence of some disease of a fatal character, as phthisis. At the "turn of life" it is sometimes succeeded by ovarian or uterine disease.

*Treatment.*—When a sudden suppression of menstruation has taken place, as in acute amenorrhœa, the natural flow is often re-established by placing the patient's feet in warm water, or else by placing her in a warm hip-bath, and exhibiting some diaphoretic medicine or drink at bed-time, when the discharge often returns in a few hours. If, however, it should be accompanied by fever, headache, and a quick pulse, dry skin, and heated tongue, some blood should be taken from the arm; a saline purgative, combined with a mild opiate, should be exhibited ter die, and hot fomentations be applied to the abdomen.

The chronic forms of amenorrhœa are best treated by tonics; and there is no class of medicines which have not maintained much reputation in this complaint, as musk, castor, camphor, or the vegetable and mineral tonics. Dr. Locock speaks of the combination of myrrh, aloes, sulphate of iron, and of the essential oil of savine, as having been highly useful in his practice. (Cyclopædia of Medicine.) In general the amenorrhœa is best treated with salicine, gr. x. ter die, or with preparations of iron, as the citrate of iron, gr. x. ter die, or Griffith's mixture; but the salicine less frequently disappoints the hopes of the practitioner than the iron, and does not heat the patient or cause headache. When the bowels are extremely confined the decoct. aloes ℥ ſs. to ℥ j. ter die may sometimes be substituted for or taken in conjunction with the other medicines. If these remedies should fail, a wide field of experiment is laid open to the practitioner. Dr. Bardesley, for instance, recommends strychnia one-tenth to one-quarter of a grain, a remedy unquestionably of great danger and of little benefit; while others recommend savine, tinct. cantharides ♏xxv. ter die, the turpentines, balsams, or guaiacum. The patient, however, had better repair to some of the natural mineral springs, as Tunbridge Wells or Cheltenham, where she can have wholesome air and exercise, rather than submit to so endless a series of medicamentations.

### Dysmenorrhœa, or Hysteralgia,

Is that affection in which the periods of menstruation are attended with great pain.

*Remote Causes.*—This affection, often constitutional, is common to barren, to epileptic, or to highly hysterical women. It sometimes arises, however, from fright, or other cause which suspends the flow of the menses.

*Predisposing Causes.*—Dysmenorrhœa is rare before the body has acquired its full growth, and is most common between twenty and thirty-five. It necessarily ceases during pregnancy and suckling, but it returns and marks the few last years of menstruation. It occurs most frequently in women of a nervous sanguine temperament, and of strong passions, and it is said more especially to affect those devoted to a monastic life.

*Pathology.*—Dysmenorrhœa unquestionably accompanies most structural diseases of the womb, but structural diseases of the womb are rare till after forty. This form of uterine disease, therefore, in the great majority of cases is purely functional.

*Symptoms.*—Catamenial hysteralgia commences most commonly two, three, or more days before menstruation. The symptoms are lumbar pains, increased by the patient attempting to stand, and also pains of the hypogastrium and umbilicus. These pains have different characters and intensities, and are described as lancinating, or stabbing, or constricted, and as if the abdomen was grasped by a powerful hand. The patient from her sufferings being unable to walk, her digestive functions are generally deranged, and her bowels constipated or otherwise affected. The mammæ also enlarge and are painful, the genital organs are swollen, a mucous discharge takes place from the vagina, the passage of urine is attended with heat, and in some cases both the bladder and rectum sympathize, and are irritable.

These symptoms increase as the period approaches, when they sometimes suddenly cease, but at other times they continue till the menstrual flux decreases, and then are mitigated. The flow is often trifling and so defective in quality and quantity as to be little more than a reddish serosity, or, being abundant, it may suddenly cease and return some days after. In other cases it is profuse, almost amounting to hæmorrhage. In the intervals, in many cases, the patient enjoys good

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health; in other cases, the pains, though mitigated, are aroused on the slightest motion, while in a very few some inflammation of the uterus, extending perhaps to the ovaries, may take place.

*Diagnosis.*—The coincidence of the attack with the periodic flow, and its subsidence after its cessation, are sufficient diagnostic symptoms of this affection.

*Prognosis.*—The symptoms of hysteralgia are sometimes so intense as to alarm and distress both the patient and her family, but life is never compromised, and the prognosis is consequently always favourable.

*Treatment.*—There are few diseases more distressing to the patient than hysteralgia, or that are altogether less under the control of medicine. During the period, however, a warm hip-bath, an opiate, and the mist. camphoræ c. sp. ætheris nitrici often afford great relief, and in recent cases of great severity some blood may be taken by cupping from the loins. In the interval the pains, it has been stated, are often mitigated, but nevertheless they are still often reproduced by every attempt to walk, and the patient is perhaps for many months confined to the sofa. Under these circumstances experience has shown that bleeding is not only of no use, but that, for the most part, it is absolutely injurious; neither do blisters produce any satisfactory results. We have, however, some resource in stimulant medicines, as camphor gr. v. to x. ter die; in the mistura assafœtidæ ℥ ſs. to ℥ j. ter die; also in salicine, iron, castor, musk, warm purgatives, and quina; and all these perhaps give relief in turn, but all at length perhaps equally fail, showing that they act rather on the mind than on the body. From this cause we should recommend change of scene, of air, and of society, together with cold bathing in the morning during the intervals, and warm baths at the particular periods. Such exercise, also, on horseback as the patient can take she should be permitted to indulge in, and her mind should be amused in every possible manner. At length these miseries subside or are suspended by marriage, pregnancy, suckling, or the approach of the "time of life." The worst cases are those which are connected with disease of the heart or with epilepsy, and in these instances no permanent relief is obtained unless the primary disease subsides.

## Of Hæmorrhages.—Order II.

Hæmorrhage is the effusion of blood into the substance of an organ, or else from some tissue of the body, and more especially from the cellular and mucous tissues. It may take place from the rupture of a blood-vessel, whether caused by a simple solution of continuity, or by an abscess or other form of ulcer. More commonly, however, hæmorrhage takes place from the capillary vessels of the part, without any rupture of vessel or breach of surface, and this latter form is that which occurs in ninety-nine cases in a hundred. The blood effused may be either venous or arterial, and the symptoms it gives rise to depend on the organ affected and the quantity of blood lost.

Hæmorrhage may be caused by a diseased action of the solids, and in this case it may be active or passive. It is passive, for instance, when it takes place in consequence of a blow which impairs the vitality of the part and allows the escape of blood into the surrounding tissues. It is passive also when the heart acts so powerfully as to overcome the capillaries of the part. There are many circumstances, however, in which it is evidently active, as in menstruation, in vicarious hæmorrhage, in some cases of inflammation, and also in many of those cases in which it is the prelude to phthisis. There are a certain number of hæmorrhages also which do not appear to originate in a primary diseased action of the solids, but which seem to result from an altered condition of the blood. Thus hæmorrhages are common when the blood contains less fibrine than in health, as in typhus and in scurvy, while they are rare in diseases in which the blood contains an excess of fibrine, as in inflammation or chlorosis. This diminution of fibrine in cases of hæmorrhage is so constant that Andral conceives it impossible not to regard the one as the cause of the other. In hæmorrhage from plethora he conceives that the fibrine remaining the same, or being diminished, the blood contains a larger proportion of red globules than in health; while in scurvy, or other depressed states of the system, the fibrine is alone diminished, the red globules remaining in normal proportion. In general, in hæmorrhage, the blood is not buffed, has a large soft clot, and if the hæmorrhage has been considerable, with difficulty coagulates, showing a diminished quantity of fibrine. Many substances also which directly contaminate the blood have the power to produce hæmorrhage. A solution of sub-carbonate of soda, injected into the veins of animals, deprives the blood entirely of the power of coagulating, and the absorption of the muriate of soda is probably the cause of scurvy. Many morbid poisons, also, as that of typhus fever or of small-pox, also have a similar tendency. Hæmorrhage, therefore, may be caused by an altered state of the blood as well as by a diseased condition of the solids, and in many instances, perhaps, is referable to both causes. One of the most general laws of hæmorrhage, according to Gendrin, is, that when blood is effused into the substance of an organ, as the brain, it is never absorbed without the process of inflammation being set up.

### Apoplexia

Is the effusion of blood within the cavity of the cranium, causing the patient suddenly to fall down, deprived on the instant of all sense and motion. This disease was well known in the Greek and Roman schools of medicine, and is of too frequent occurrence and of too striking a character to have escaped observation even in the rudest ages of society. In the year 1839, 5293 persons died of apoplexy, and 4910 of paralysis, probably in consequence of apoplexy, in England and Wales, thus giving one death in thirty-three from this cause in our own country.

*Remote Cause.*—Among the most frequent causes of apoplexy is an intemperate use of fermented liquors, a class of substances which not only powerfully excites and powerfully depresses the action of the brain, but also acts specifically on the heart and arteries, causing not only temporary energetic action of those parts, but also organic alterations in their structure. In the latter case the powers of the heart are often permanently augmented, while the coats of the arteries, thickened and thinned, or ulcerated, have their elasticity destroyed, and the tendency to hæmorrhage of the brain increased. The excessive use of narcotics, as opium or tobacco, is also supposed to predispose to congestion of the brain, and consequently to cerebral hæmorrhage. The bon-vivant, the indolent, and the sedentary person is the most frequent victim of this disease, from his usually plethoric habit.

Extremes of temperature, also, are powerful predis-



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ponents to apoplexy; for in summer the fluids are expanded and the tone of the capillaries impaired, while in winter the cold drives the blood from the periphery of the body to its central organs, and consequently to the brain. Sudden and great vicissitudes of the weather, as they rapidly exhaust the nervous power, are more frequently fatal than the uniform continuance of its extremes, and these have been considered, on more than one occasion, as the cause of apoplexy prevailing to such an extent at Edinburgh and Rome as to be almost endemic.

The greater number of deaths from apoplexy in France, says Gendrin, during the last half century, has shown the powerful effects of *moral causes* in producing this fatal disorder. No times were ever more fruitful in conjunctions calculated to excite the passions and to rouse the moral feelings. Fortunes were broken, the bonds of relationship destroyed,—the cares of envy and of intrigue, the wounds of calumny, the dreams of ambition, the activity of political hatred, weighing still more heavily on the oppressor than on the oppressed, were all in their fullest activity, unchecked by any true principle of religion or of sound philosophy.

Mechanical obstruction is also a frequent occasion of apoplexy. If an obstacle, for example, be opposed to the course of the blood, as when the valves of the heart are diseased, the blood accumulates in the capillary system generally, and consequently in the brain. Apoplexy is still more common when the aorta is diseased, the force of the heart, unchecked by the elasticity of that vessel, acting directly on the brain, so that its vessels often give way from this cause. Mechanical violence, also, often produces apoplectic effusion. Thus a concussion of the brain always produces temporary congestion of that organ, while, if severe, effusion may take place behind the dura mater, or between the membranes, as well as into the substance of the brain, which may be extensively ruptured. A workman fell into a well, fractured both his legs, and died two hours afterwards. In this case a large apoplectic *foyer*, filled with blood, existed in the brain, which had so lacerated its substance that both the lateral ventricles communicated.

*Predisposing Causes.*—Apoplexy occurs even in some few instances in childhood. Billard gives the case of a child that died apoplectic at three days old from effusion into the left hemisphere and about the lateral parts of the corpora striata. Serres also saw a similar case in a child three months old. Apoplexy, however, is extremely rare till puberty, and only a few cases are met with before twenty. It is not unfrequent between thirty and fifty, while after fifty it is one of the most frequent causes of death. There are many circumstances which favour the occurrence of apoplexy in old age. At that period the capillary system becomes in part obliterated in all organs, and thus the veins are filled with a greater quantity of blood, or become congested. The cerebral arteries also are often diseased; the heart also has frequently acquired an abnormal power, driving the blood with great violence towards the brain, while the lungs have their functions impaired, so that the blood is only imperfectly oxygenated; and all these are causes of congestion and of tendency to rupture of the vessels of the brain.

Both sexes are liable to this affection, and in nearly equal proportion; the number of deaths in the male population of this country in 1839 being 2809, and of the female portion 2484. The party most liable to attack is florid in complexion, short in the neck, prominent in the eye, broad in the chest, protuberant in the belly, and loaded with fat, and sometimes enormously so. Many thin persons, with spare long necks, however, frequently fall from apoplexy, but it is probable in these cases that their heart, or large vessels, must be diseased. As form descends, a large number of apoplexies appear to be hereditary, and many successive generations fall from this complaint. It is common also in families.

The act of digestion appears to predispose to apoplexy, for numbers are attacked after dinner. Sleep, also, which many physiologists suppose to be caused by a temporary congestion of the vessels of the brain, is another predisposing circumstance. Thus of 176 cases examined by Gendrin, 97 had been attacked during sleep.

Many diseases also predispose to apoplexy, as mania, epilepsy, also suppressed hæmorrhoids, amenorrhœa, and especially the "turn of life," and probably from the plethora they induce.

*Pathology.*—Some very few cases have died from apoplexy when nothing has been found but congestion of the vessels of the scalp, of the membranes of the brain, and of the brain itself, but without the extravasation of a particle of blood, so that the party has fallen from mere pressure on the brain, caused by the apoplectic orgasm. The rule, however, in apoplexy, is, that a greater or less quantity of blood is effused either into the cavity of the arachnoid, or else into the substance of the brain, or into both in every case. When the quantity is trifling, the disease is seldom fatal on the first attack, so that in examining apoplectic cases it is not unusual to find a cavity scarcely bigger than an oat in the substance of the brain, the evidence of the primary attack, and containing perhaps a dry clot of blood. On the contrary, if the blood be effused among the membranes, it may be altogether absorbed, and not a trace of disease be found. In severe cases, still greater quantities of blood are effused, while, if the apoplexy be "foudroyante," and destroy the patient in a few minutes or a few hours, the quantity of blood effused will sometimes fill the whole cavity of the arachnoid, or extensively rupture the substance of the brain, forming a cavity as large as a nut or an egg, or even lay the ventricles one into the other.

It is rare that sanguineous effusion occupies both cerebral lobes, or the whole extent of the membranes of the brain, although such instances are occasionally seen. More commonly it is limited to the substance of one hemisphere, or to the membranes covering it. When the membranes of the brain are affected, the more immediate seat of the hæmorrhage is usually that portion covering the convexity of the brain. This varies, however; and the portion covering the base, or that investing the cerebellum, or indeed any other part, may be its seat.

The superficial membranes of the brain are not the only membranes of that organ which are the seat of apoplectic effusion, for hæmorrhage may take place from the membrane lining the ventricles, and which sometimes bleeds so profusely as not only to fill the lateral ventricles, but even to enlarge their cavities. As death in these severe cases is usually sudden, the walls of the ventricles are generally healthy, but in some very few instances the septum lucidum has been found ruptured, so that the ventricles have communicated. No case, however, is known of a simultaneous effusion into both lateral ventricles. The smaller ventricles are in a very

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few instances also the seat of apoplectic effusion, Dr. Abercrombie having given a case in which the third and fourth ventricles were filled with blood. This patient was not at first insensible, but gradually became so, and died in a few hours.

The appearance of the blood effused into the membranes of the brain varies according to the time which elapses before the patient dies. If that event takes place in a few hours after the attack, the blood is still fluid, or else is found in black clots, while the membranes, except being infiltrated with blood, are as yet healthy. The substance of the brain, likewise, has no other appearance of disease than being flattened from the pressure of the extravasated blood. If the patient, however, survive a few days, the membranes show marks of inflammatory action, are injected, thickened, and although dry and pitchy in the immediate neighbourhood of the clot, have yet some serum effused in other parts of their cavity. The convolutions of the affected part of the brain are likewise now not only flattened, but softened (ramollie).

When effusion has taken place into the substance of the brain, if the patient has died in the fit, or shortly after, the hæmorrhagic *foyer* is found filled with half-coagulated blood, its walls irregularly softened, and dyed for some lines in thickness with the colouring matter of the blood; and a small stream of water thrown upon this part at once removes the extravasated blood, and also a layer of cerebral matter. Again, if the patient has survived a week, the blood is found coagulated, and the serum set free; but the presence of the clot has caused inflammation, so that the walls of the cavity are not only discoloured but softened, and are softer in proportion as they are nearer the clot. If life be prolonged till the fifteenth day, the serosity is absorbed, but the walls of the cavity are still of a deep red. About the thirtieth day, if the patient live so long, the clot is isolated, and a membrane forms, at first muciform, fragile, intermixed with particles of cerebral matter, and also with some of the colouring matter of the clot. By degrees, this membrane becomes more consistent, the clot diminishes, and some serum is probably secreted by the new membrane surrounding it. The cerebral walls surrounding the cyst, before softened, now become indurated, and are stained yellow from the usual changes which the extravasated blood with which they are penetrated undergoes, a colour however which they ultimately lose. The cavity thus formed is at length, perhaps, filled with nothing but serum, or, the serum being absorbed, the membranous cyst may ossify, and be thus converted into a bony tumor. At other times, the opposite sides of the cavity unite by a kind of cellular membrane, which thus forms a species of cicatrix, but possessing so little power of conducting nervous influence that the patient seldom recovers from his palsy. Such is a short outline of the effects of hæmorrhage into the substance of the brain. The size of an apoplectic *foyer*, it has been stated, varies from an oat to that of an egg, and their number is as variable as their extent. Sometimes we find but one, sometimes two, and in a very few instances three or more. When many *foyers* exist in the brain, it is rare to find them all in the same state, for some are old and almost obliterated, others are fresher, and others again quite recent, their different stages marking a distinct and different period of attack. As to the particular seats of the apoplectic effusion, Andral has collected a series of cases, and found the following to be the order of their frequency:—

| | |
|---|---|
| Effusion into that part of the cerebral hemispheres situated on a level with the corpora striata and thalami opticorum, and at the same time into those two centres | 202 |
| Effusion into the corpora striata | 61 |
| Thalami opticorum | 35 |
| Portions of the hemispheres situated above the centum ovale | 27 |
| Lateral lobes of the cerebellum | 16 |
| Before the corpora striata | 10 |
| Mesocephalus | 9 |
| Spinal cord | 8 |
| Behind thalami opticorum, or in the posterior lobes | 7 |
| Median lobe of cerebellum | 5 |
| Peduncle of the brain | 3 |
| Peduncle of the cerebellum | 1 |
| Corpora olivaria | 1 |
| Pituitary gland | 1 |
| | 386 |

Many pathologists affirm that apoplexy is caused by rupture of the blood-vessels in every case, although they admit this state of parts can rarely be demonstrated, the ruptured vessels being generally less than one-third of a line in diameter, and consequently too small to be manifest to sense. That rupture of vessels is occasionally the cause of cerebral hæmorrhage there can be no doubt, for Rochoux, Abercrombie, and others, have collected instances of the rupture of the larger superficial vessels of the brain, as of the carotid, the basiliary, and of the meningeal arteries, these vessels being either aneurismal, ossified, cartilaginous, or otherwise previously diseased; but even these cases are very rare.

It is certain also that the large encephalic veins are in a very small number of instances found ruptured in apoplexy, as the venous sinuses. As a general rule, however, apoplexy is the result of an hæmorrhagic action or exudation from the coats or mouths of the capillary vessels.

It has been a favourite object with pathologists to connect the lesions of the brain, found after death, with the symptoms during life. But apoplexy has not furnished us with any analysis of the organs of the mind. It has, however, determined one general law with respect to motion, or that the power of volition is crossed, each hemisphere commanding the motions of the limbs of the opposite side. The theory of apoplexy is of considerable difficulty; the quantity of blood effused is often so small that it is impossible to account for the symptoms from mere pressure. It is probable, therefore, that the blood effused is a consequence of an apoplectic orgasm residing in the brain itself. The subsequent palsy of course depends on pressure or other injury done to the brain.

*Symptoms.*—Encephalic hæmorrhage may take place suddenly, and while the patient is in his best health. More commonly, perhaps, it is preceded for a few hours or a few days by giddiness, by fulness, weight, or severe pain of the head; by deafness, noise in the ears, or by violent palpitation of the heart. In other cases the mind is affected, and the memory or other faculty sensibly impaired; or the patient has a feeling of numb-



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ness in his fingers, or is deluded by optical illusions. At length the *fit* of apoplexy takes place, and in one of three degrees of intensity, termed by Rostan *apoplexie faible*, *apoplexie moyenne*, and *apoplexie forte*.

The distinguishing symptom of these different degrees is the mode in which the fit terminates. In the first degree, the patient recovers with the entire use both of his limbs and of his mental faculties. In the second degree, if he is restored, one or more of his limbs are palsied, and his mind more or less impaired; while, in the third degree, he dies in the fit, seldom giving any sign of sense, of motion, or of intelligence.

The symptoms of the first degree, or *coup de sang*, *ou apoplexie faible*, *ou fugare*, are that the patient, on the instant of his seizure, suddenly becomes insensible, and if standing, he falls to the ground; or, if sitting, he makes perhaps a convulsive effort to rise; or else his head falls on his chest, as in a deep sleep, but his face is pale or purple, his mouth often drawn, and his eye fixed, with the pupil insensible to light. In whatever position, however, he may be seized, his limbs, when raised, fall by their own gravity; his pulse, though not greatly accelerated, is full, and the carotids are in strong action. His respiration is slow and deep, and the temperature of the head and neck is increased, but that of the extremities diminished.

The duration of the fit in this mild form of the disease is very various, sometimes lasting only a few minutes, and seldom exceeding two or three hours. The first symptoms of recovery are, the nose becoming sensible to irritants, the eye to light, and then succeed a few convulsive movements, a few deep-drawn sighs, and the patient is restored to consciousness; he has, however, no recollection of what has passed; his looks express astonishment, his tongue is swollen, and his replies slow; he remains enfeebled in body and in mind for a few days, but at length recovers, nevertheless often bearing about him, and for a long time, marks of the shock his brain has sustained.

It is rare that the *coup de sang* is not renewed, for more generally it is only the commencement of a series of attacks which ultimately destroy the patient. Popular opinion supposes the patient to suffer three apoplectic attacks, the first being mild, the second followed by paralysis, while the third is fatal. It is only in a few instances that this number is exceeded.

In the second degree of apoplexy, or *apoplexie moyenne*, *ou paraplexie*, the symptoms of the fit are similar, only more severe and last longer, or perhaps from two to twelve or fourteen hours, and on the patient recovering it is found that many important functions depending on the brain are profoundly and permanently impaired. These lesions are most usually hemiplegia, or palsy of one side of the body, and perhaps of one side of the face or of the tongue. In other cases, however, only one limb, or part of a limb, is affected, as an arm, the fore arm, or a hand; while in others it is only one leg, which, if the attack be mild, the patient is able to move in bed, but if he attempts to walk, it drags, or else, it being too feeble to support the weight of his body, he falls down. In other rare instances the paralysis is crossed, the arm of one side and the leg of the other being affected; or the patient is paralyzed, both arms or both extremities being palsied.

In some cases only one set of muscles is palsied, generally the extensors, so that the leg may be forcibly bent against the buttock, or the fore arm flexed upon the upper arm. Sometimes, however, the extensors are alone affected, so that the knees may be drawn up to the chin.

If the patient survives any length of time he usually recovers some use of his leg, so that he is able to walk with a "straight leg" and a dragging foot; but the use of his arm returns more slowly and more imperfectly. This recovery is often preceded and accompanied by very severe pains, especially of the upper extremity, marking the still irritated state of the brain. The limb, however, uniformly wastes, and its vital powers are so impaired that if inflamed the inflammation seldom terminates by resolution, but has a great tendency to gangrene, while cicatrization is slow and difficult.

The abolition of sensation is complete during the fit, but in general the patient entirely recovers all his senses. In some cases, however, he is affected not only with palsy, but also with anæsthesia, so that you may prick, pinch, or burn the affected limb without giving any pain. In other cases, again, the patient is palsied on one side, and deprived of all sensation on the other; in others the anæsthesia exists without the palsy. In a patient lately in St. Thomas's Hospital, the right arm, without being palsied, was so numbed or affected with anæsthesia after apoplexy, that the party was unconscious of what he held in that hand, and consequently when not looking at it let everything fall. One side of his face was also in a similar state of insensibility. In general the patient recovers the sensations of the part before he acquires the power of moving it, but in other cases the event is reversed, and he recovers the use of the limb although it remains permanently in a state of anæsthesia.

The apoplectic patient in some rare cases labours under amaurosis, or else objects appear to him black and without any determinate form, or he sees only one-half of an object, or else one-half appears of one colour and the other half of a different colour. Deafness is very unusual after apoplexy, but the loss of the senses of smell and of taste are very common.

It is singular that parts struck with anæsthesia do not waste as in palsy, neither are they exempted from the action of many morbid poisons. A patient, for instance, was seized with small-pox while labouring under anæsthesia of the arm, when the diseased limb was equally affected with the sound one. Another affected by anæsthesia of the face, was seized with erysipelas of the face, when he presented the curious fact of suffering much pain on the sound side, but was entirely free from pain on the affected side.

The patient, on recovering from the attack, has sometimes the good fortune to recover all the faculties of his mind, but more commonly his memory is impaired often to such a degree that he has forgotten all dates, the names of his friends, or even the names of things. Broussonet, professor of medicine at Montpellier, had entirely lost the remembrance of all noun substantives, and another case is given in which the patient lost all his adjectives. In some instances the power of association is also so destroyed that although many remember both names and things, they are unable to connect the thing with the proper word, so that they call that which is cold, hot; or speak of night when they mean day; or call a coffee-pot a wash-hand basin. Others, again, have forgotten how to read, and the power thus lost either returns suddenly, or else they are obliged to learn *de novo*.

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The attention is also very greatly impaired, and the patient is no longer able to transact business; or if he begins a sentence is unable to finish it, or he repeats the same idea over and over again. The passions also are little under control, for some weep like children; others laugh immoderately, and all are easily terrified, or otherwise easily acted upon.

Nothing is more variable than the time of recovery after a paralytic attack. In a very few instances the patient is restored in a few days, or in a few weeks, or in a few months, but more commonly the lesions of motion as well as of the mind are permanent, or nearly so. In general, however, some slight improvement takes place even in the worst cases, so that the patient recovers some use first of his leg, and then, perhaps, of his arm.

The adverse circumstances attending recovery from apoplexy are, that although the patient appears to be doing well the first few days after the attack, yet towards the close of the first week the brain, irritated by the presence of the clot, inflames and softens, and thus induces another and a fatal attack of apoplexy. Should the patient, however, survive this dangerous period, he may continue to live many months, or years, according to his age; but he is generally at length cut off by a fresh attack of apoplexy, or else his brain ultimately inflames and softens, and he dies in a typhoid state.

The third degree of apoplexy, or *apoplexie forte*, or *foudroyante*, is that in which the patient lies almost without sense or motion, his face purple and swollen, his eye half open, his respiration stertorous, and his extremities cold, although his pulse is often natural. From this state nothing rouses him, or only to some ejaculation indicating uneasiness. The symptoms which have been mentioned show that the eighth pair and the phrenic nerves are affected, and this is generally followed by the symptoms termed "*fumée la pipe*," denoting palsy of the seventh pair, and in this state the patient dies sometimes in a few minutes, and rarely survives more than a few hours.

*Diagnosis.*—Apoplexy is distinguished from epilepsy by the absence both of convulsions and of foaming at the mouth; and from *ramollissement* of the brain by the suddenness of the attack.

*Prognosis.*—Apoplexy is always a grave disease, and the more grave in proportion as the respiration is stertorous and the deglutition difficult. When the symptom termed *fumée la pipe* is present recovery is nearly hopeless. Each succeeding attack is more dangerous than the former. The practitioner should be guarded in his prognosis till after the first week or ten days, lest inflammation should come on, or a fresh attack destroy the patient.

*Treatment.*—The patient, if seen during the fit, should be bled, and bled copiously, in order to relieve the congestion, and also to check, if possible, a further effusion of blood. The quantity taken should be proportioned to the degree of stertor and to the powers of the patient; and sixteen, twenty, and even thirty ounces may be allowed to flow. If the latter quantity is not followed by some degree of consciousness, it may be inferred that the amount of blood effused is considerable, and that the patient in all probability will not recover. Still, perhaps, an additional chance will be given by applying cold to the head, leeches to the temples, and mustard cataplasms to the feet, also by placing a drop or two of croton oil on the tongue, and by throwing up a cathartic enema of castor oil or other medicament, but not one of turpentine, as is commonly done, for the intoxication that produces must be decidedly injurious.

Some persons are disinclined to any considerable bleeding during the fit, considering that the bony structure which contains the brain removes all atmospheric pressure so entirely as to cause that organ at all times to contain an equal quantity of blood. The brain, however, is not a mechanical syphon, but a living machine governed by vital laws; has a space for a very sensible expansion and contraction at each pulsation of the heart, while posthumous examination shows it to contain very different quantities of blood, it being sometimes gorged, and sometimes blanched of blood. These facts distinctly show that it must possess the power of regulating the quantity of blood sent to it; and we ought therefore in a disease of this moment to follow the dictates of a long experience rather than the conclusions of a fallacious reasoning.

After the patient has in some degree revived, and the congestion consequently removed, we may pause for a few hours and allow some time for the absorption of the blood effused; for any very large depletion after that point is gained would rather facilitate extravasation than prevent it. A few hours then having elapsed, the conduct of the practitioner should be guided by the *pain of the head*, which may be taken as a measure of the fulness of the brain, and its tendency to inflammation. If, therefore, there be pain in the head, ten to twelve leeches should be applied from time to time till that symptom is entirely relieved; or, supposing the pulse to be full and strong, and the patient free from headache, yet under these circumstances leeches should be applied to the head to anticipate that re-action which so generally takes place from the fourth to the seventh day.

The further treatment of the case is by moderately purging the patient, both as a means of relieving the head, as also of improving the secretions of the alimentary canal, which are often black and fœtid; and five grains of calomel given as soon as the patient can swallow, and followed up by a black draught, or by sulphate of magnesia ʒj. out of camphor mixture every four or six hours, and continued according to its effects for a greater or less length of time, are, perhaps, the best means we have for promoting the recovery of the patient, and for preventing a relapse. The foregoing prescriptions are recommended on the supposition that the attack has been caused by simple plethora. In many cases, however, it is a consequence of hypertrophy of the heart; and in such cases less blood should be taken, and eight to ten minims of digitalis be added to each dose of the purgative medicine, or the pulv. seminarum iberidis, grs. iij. to v. ter die should be substituted.

All apprehension of a relapse being at an end, the patient is in general most willing to believe that the palsy is a mere local disease, and to submit to any treatment for its removal. The ancients applied actual cautery to the extremities, to the coronal suture, or to the occiput, but without, as it is understood, any beneficial success. The moderns have had recourse to blisters, to friction, to electricity, and to strychnine; but every attempt to act locally on the muscular system may be stated to have failed. In those few cases which are capable of being relieved, and they are but few, the secale cornutum grs. x. ter die has appeared the most efficient remedy.

*Dietetic Treatment.*—The diet of the patient should, till all apprehension of a relapse is passed, be low, and

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limited to milk, boiled vegetables, light puddings, and fish; and at no subsequent period ought he to indulge in a full animal diet, or to drink undiluted wines.

### Of Epistaxis.

Epistaxis is a hæmorrhage from the mucous membrane of the nose.

*Remote Cause.*—Everybody knows that a blow, exposure to a high temperature, crying, or any violent muscular exertion, may be a cause of epistaxis. In some cases it is occasioned by worms, while in others it is constitutional. Some morbid poisons also give rise to it, as that of scurvy, fever, and small-pox.

*Predisposing Causes.*—This disease occasionally occurs in children of three or four years old. Gendrin mentions a family of three children who suffered every five or six days from epistaxis, from the age of eight to fifteen years old. More commonly it attacks adults between fifteen and twenty-five; no age is entirely exempt from it. Women are equally if not more predisposed to this disease than men, and especially when suffering from amenorrhœa. Hoffman conceives epistaxis to be often hereditary, and has seen it run in families.

*Pathology.*—Epistaxis in an immense majority of cases is merely the result of an hæmorrhagic action from the nasal membrane without any breach of surface. Indeed, if the hæmorrhage, as is often the case, proceeds from a point low down in the nostrils, the blood is seen to exude from the surface of the sound mucous membrane, only slightly injected.

*Symptoms.*—The attack of epistaxis may be sudden, or it may be preceded by weight or pain in the head; by heat, redness, or itching of the nostril. As soon as the hæmorrhage is established, the blood issues forth generally in drops, and only rarely in a continued stream, and very seldom from both nostrils. The blood effused at length coagulates; and if on the part from which the hæmorrhage proceeds, the flow of blood ceases; if not, it continues to flow externally, or if internally, down the pharynx.

The quantity of blood lost is very various, sometimes only a few drops, more commonly half an ounce to two ounces; while in other cases it may amount to some pounds. The duration of epistaxis is ordinarily short, often only a few seconds or a few minutes, but in a very few cases it lasts from one to two hours, and has been known to last twenty-four hours. In these latter cases the patient is greatly exhausted, blanched, and leucophlegmatic, his legs swell, and his appearance is perfectly chlorotic.

*Diagnosis.*—The only difficulty in the diagnosis of epistaxis is when the blood escapes posteriorly by the pharynx instead of anteriorly and by the nostrils.

*Prognosis.*—Nasal hæmorrhage is rarely dangerous; in a few instances, however, it is so copious that the patient is greatly exhausted; still, in general, so far from being dangerous it is favourable to health by dissipating headache, and a tendency to cerebral congestion. It has been observed that persons subject to epistaxis when children, easily contract grave diseases of the chest, as hæmoptysis, pleurisy, peripneumonia, and even phthisis in youth; while in more advanced age they become subject to hæmorrhoids, rheumatism, or gout.

*Treatment.*—Slight cases of epistaxis require no treatment, and hardly any attention. In severer cases cold water, applied by a sponge to the nose, putting the hands in a basin of cold water, and perhaps putting the key of the street door down the back is sufficient to arrest it in a few minutes. If the bleeding should continue after these means have been tried, Valsain found that the hæmorrhage often proceeded from a point so near the extremity of the nostril that it could be compressed by the finger; and he mentions having cured in this manner a case of epistaxis which had burst forth every year for four years. If the seat of the hæmorrhage is beyond the reach of the finger, a pledget dipped in some styptic, as a solution of alum, or of the sulphate of zinc, or sulphate of iron, should be passed up the nose. If the hæmorrhage is very great, and the above methods unsuccessful, it is necessary to plug the nose. This is effected by passing up the nostril a bougie to which a double thread is attached; by means of the one a pledget is to be drawn through the mouth into the posterior nostrils, while another pledget is to be drawn up through the nostril. In this manner the anterior and posterior nostrils are equally blocked up, and the blood, unable to escape, coagulates, and the hæmorrhage is stopped. This operation, trifling as it is, always causes headache, and is painful to the patient. The pledgets should be allowed to remain two or three days and then withdrawn, the coagula now beginning to undergo decomposition, and to become offensive. In cases where the tendency to nasal hæmorrhage is great, the mineral acids, as the inf. rosæ c. acidi sulph. dilut. ♏ iij. to ♏ v. should be exhibited, or, perhaps, what is still better, the bitartrate of potash, ʒ ſs. to ʒ j. bis die, and the general health of the patient should likewise be attended to and restored.

The patient's diet should be light, and the quantity of animal food be either diminished, or for a time be abstained from altogether; light French wines should be preferred to port or sherry, and he should avoid any severe study or exercise.

### Hæmoptysis, or Bronchial Hæmorrhage.

Hæmoptysis is an hæmorrhage from the lungs.

*Remote Causes.*—Hæmoptysis may proceed from heat or cold, or sudden transitions of temperature, or else from variations of atmospheric pressure, as from ascending a high mountain, or descending in the diving-bell. It may result also from over-exertion, from plethora, from mechanical violence, and from a violent and disturbed state of the passions.

More commonly hæmoptysis is symptomatic, and results from amenorrhœa, from diseased heart, and more especially from phthisis. Pneumonia is also very constantly attended by hæmoptysis, and consequently every morbid poison which produces inflammation of the lung is a cause of hæmoptysis, as the poison of small-pox, of hooping-cough, of the paludal poison, and also of scurvy.

*Predisposing Causes.*—Schmidtman, in a practice of thirty years, has seen hæmoptysis seven times in infants. Gendrin once saw it in a child eight years old. More generally, however, it is a disease incident to adolescence, and to the earlier part of riper age. Borrieri limits it between twenty-two and thirty-five; but Frank, with more propriety, extends it from sixteen to thirty-six; but it occurs in cases of diseased heart, and also in phthisis at still later periods. The hereditary tendency to hæmoptysis is as incontestible as to that of phthisis.

*Pathology.*—When the patient falls after an attack of idiopathic hæmoptysis, the bronchial tubes of the affected lung are found more or less filled with fluid or coagulated blood; but in ninety-nine cases out of a hundred the minutest examination is unable to discover

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the slightest structural lesion, except perhaps some slight congestion of the bronchial mucous membrane. It seems proved, therefore, that hæmoptysis is caused, in the vast majority of cases, by an hæmorrhagic action of the bronchial membrane, and only in a very few rare instances by rupture of a blood-vessel. Even when the hæmoptysis follows the deposition of tubercular matter which has terminated in abscess, still the hemorrhage, with some very rare exceptions, always comes from the bronchial membrane, the tubercular deposit constantly turning the blood-vessels aside, or else obliterating them, so that perhaps not in one case in five hundred does a blood-vessel traverse the abscess, or is in any way exposed to ulceration or to rupture. It is rare that the hæmoptysis takes place from both lungs. The particular seat of hæmoptysis is *supposed* to be the larger bronchi; for if excessive hemorrhage should take place from the smaller bronchi, it is apprehended the patient must die suffocated. Many other diseases besides phthisis, and especially disease of the heart, are found to co-exist with hæmoptysis.

*Symptoms.*—Hæmoptysis may take place suddenly, or be preceded by a sense of heat or a feeling of weight at the chest, or the patient may suffer pain between the back and shoulders, or may labour under dyspnœa, palpitation, cough, or coldness of the extremities, and these symptoms may last two or three days. At length the party is seized with a fit of coughing, or a tickling of the throat, and then vomits up sometimes arterial but more often venous blood. The quantity is very various, sometimes not more than streaks the sputa, at others a few ounces, or else some pounds, terrifying both the patient and the bystanders by its vast amount. Laënnec says he has seen as much as ten pints thrown up in forty-eight hours, and as much as thirty pints in a fortnight. The effort of coughing also often causes vomiting, so that the blood discharged is frequently mixed with alimentary matters.

If the quantity thrown up be inconsiderable, the patient's previous health is in no degree affected; but if it be large its effects are strongly marked, for the patient feels oppressed at the præcordia, breathes with difficulty, and with a gurgling sound, caused by the air passing through the viscid blood retained in the bronchi; and this is shortly followed by increasing weakness, even to complete prostration. In still severer cases, as the blood flows the patient turns pale, his countenance becomes œdematous and strongly expressive of terror, or else he falls into a complete syncope. In a very few instances the effusion is so sudden and so considerable that the patient dies suffocated.

It is customary for bronchial hæmorrhage, when considerable, to diminish rapidly, so that at the end of some hours only a few rare isolated sputa are spat up, and at considerable intervals. Usually, however, the hæmoptysis recurs after a greater or less length of time, but not perhaps to the extent of the primary attack.

After the patient has lain for a greater or less length of time in this state of depression a re-action takes place. In sthenic persons the appetite becomes increased, they enjoy everything they are allowed to eat, and after some slight febrile action they rapidly recover. In the fatal cases the pulse becomes rapid, the tongue brown and dry, and the patient sinks with every typhoid symptom. In hæmoptysis the resonance of the chest is in general natural, while the stethescopic sounds vary according to the amount of blood retained in the bronchi. In many cases no abnormal sound exists, in others there is some slight mucous rhonchus, which perhaps ultimately becomes tracheal, and denotes the extreme danger in which the patient lies.

*Diagnosis.*—The only disease which it is important to distinguish from hæmoptysis is hæmatemesis, and the diagnosis between them is difficult, as the contents of the stomach are often rejected in both cases. The stethescope, however, greatly assists in determining the seat of the disease; and, again, blood is generally found in the stools in cases of hæmatemesis, while it is for the most part wanting in hæmoptysis.

*Prognosis.*—Idiopathic hæmoptysis, the lung being healthy, unless the quantity of blood lost is very considerable, is seldom dangerous. When, however, the heart, the lung, or the spleen is extensively diseased the prognosis is always unfavourable, and in proportion to the amount of blood lost.

*Treatment.*—In idiopathic hæmoptysis, the lung and other viscera being sound, it is seldom necessary to bleed the patient, for if the quantity of blood thrown up be large that operation is often dangerous, and if small unnecessary. There are a small number of cases, however, in which bleeding may be necessary, as when the pulse suddenly becomes small and frequent without the powers of the patient being greatly depressed, for this symptom is the forerunner of a renewal of the hemorrhagic orgasm. The medicines most useful in this form of hæmoptysis are the bitartrate of potash ʒ j. 6$^{\text{tis}}$ vel 4$^{\text{tis}}$ horis, and to each dose of which may be added a quarter to half a grain of opium. Other practitioners prefer the mineral acids, as the infusi rosæ c. acid. sulph. dilut. ♏iij. to ♏x. c. tinct. opii ♏iij. to ♏v. 4$^{\text{tis}}$ vel 6$^{\text{tis}}$; larger doses of the dilute sulphuric acid have often been tried, but have constantly failed, being either rejected or else acting injuriously on the coats of the stomach. Many practitioners use plumbi acetati, gr. j. to gr. iij. 6$^{\text{tis}}$ vel 4$^{\text{tis}}$ horis, with half a grain of opium to each dose; and, according to Andral, when the system has long been under the influence of lead, the red globules suffer a great diminution; but, nevertheless, this is certainly a less efficacious medicine than either of the preceding ones. The nitrate of potash has been much used in France, but Gendrin has not found it efficient, or not more so than any other diuretic. The secale cornutum does not appear to possess any power over this disease. The muriate of soda in ʒ fs. to ʒ j. doses is in estimation with some practitioners on the continent.

When hæmoptysis is connected with amenorrhœa, preparations of iron often succeed when the above remedies have failed. Two grains of the sulphate of iron out of Infusi rosæ, with ʒ j. to ʒ fs. of the sulphate of magnesia ter die, often restores the menstrual secretion, and cures the hæmoptysis. Indeed it is in this form of amenorrhœa that iron is most successful.

When hæmoptysis depends on disease of the heart, cupping from the chest or moderate bleeding from the arm is often efficacious, and always admissible. The medicines should now be the bitartrate of potash or the mineral acids, to which should be added ♏v. to ♏x. of the tinct. digitalis; it is in many cases proper to add ʒ fs. to ʒ j. of the sp. ætheris nitrici to each dose, to give tone and steadiness to the otherwise rolling action of the heart.

When hæmoptysis is produced by the presence of tubercles in the lungs the case is nearly hopeless. Bleeding only the more surely destroys the patient, and the

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mineral or vegetable acids, as they have no power to heal the lung, so they are merely palliatives. They are, however, the best we possess, and therefore should be exhibited, combined perhaps with an opiate.

When the hæmoptysis results from a disease of the spleen, the patient is often supported through a first attack by wine and acids, but the hæmoptysis returns and usually destroys the patient.

When hæmoptysis is connected with inflammation, either from a specific or other poison, the treatment will be pointed out under the particular head of such disease.

*Dietetic and general Treatment.*—The patient should be placed in bed, with his head and shoulders raised; the window should be partly open so as to keep the room cool. Dr. Drake recommends that the air respired should pass through a tube containing ice; but as this experiment does not seem practicable, it is more common to place a bowl of ice immediately before the patient's mouth. Some practitioners have recommended ice to the chest; but this often causes great anxiety and constriction of the chest, and is of doubtful efficacy.

The bed-clothes should be light. The diet should be slops, and these slops cold, and if cooled to a low temperature by ice so much the better.

### Pulmonary Apoplexy

Is an effusion of blood into the cellular substance of the lungs.

Latour appears to have been the first to describe this disease, in his *Hist. Philosop. et Méd. des Hæmorrhagies*, t. i. et ii., p. 220. Orleans, 1815; and he gave it the name of *opoplexie pulmonaire*, and the term has been adopted by Laënnec.

*Remote Cause.*—Pulmonary apoplexy probably results from all those causes to which pathologists have attributed hæmoptysis. The worst cases, however, are generally seen to be connected with extensive disease of the heart. Morton mentions a singular case, in which a nail had made its way in a fit of laughter into the trachea, and produced pulmonary apoplexy. In a recent case at St. Thomas's Hospital, a patient that had scurvy died of pulmonary apoplexy.

*Predisposing Causes.*—This disease is rare, and has hitherto been observed only in adults.

*Pathology.*—In pulmonary apoplexy, when the effusion is trifling and the patient survives for some time, an induration at one or more points of the lung, and exactly circumscribed, is found, caused by an incorporation of the infiltrated blood with the tissue of the lung. These indurations may be black, brown, or red, and if scraped with the scalpel a half coagulated blood escapes, while the surrounding tissues are healthy, or only more or less congested. If the patient perfectly recover, either no trace of disease is found, or else the effused blood is absorbed, and the seat of apoplectic effusion, according to Laënnec, is marked only by a linear cicatrix, denoting an antecedent rupture of the cells of the lung. In graver cases, and when life is quickly extinguished, the blood effused into the lung is in considerable quantity, half coagulated, and the pulmonary tissue so broken down that it is impossible to demonstrate its structure, or to assign the limits of the *foyer*. In the worst cases the lung ruptures, and the effused blood escapes into the cavity of the chest. The bronchi, in most cases, also, are more or less loaded with blood.

*Symptoms.*—The symptoms of pulmonary apoplexy have various degrees, or the effusion may be slight and the patient recover, or it may be extensive and the patient survive some days, or it may be so sudden and considerable as to cause the immediate death of the patient.

The *first degree* of pulmonary apoplexy, it is supposed, can be determined during life; and if so the symptoms must be a sudden difficulty of breathing, some expectoration of blood, some mucous rhonchus, and a total inability for a time to lie down. On percussion of the chest, also, that portion which corresponds to the seat of the disease must return a dull sound. Gendrin is of opinion that blood cannot be effused without causing inflammation; and he conceives, if the patient recovers, pneumonia of little intensity always follows.

In pulmonary apoplexy of the *second degree*, the symptoms which have been described exist, but in a greater degree, so that the patient is more oppressed in his breathing; he is obliged to be supported by pillows, and his head often falls forward, while his face is purple, and his pulse small and frequent; yet, however formidable these symptoms are, life is still capable of co-existing with them for some time. Professor Mahon, of the Faculty of Medicine at Paris, only sunk after some days from apoplexy of the lung, and which had caused rupture, with effusion of blood, into the cavity of the chest. Another case, a woman, is supposed to have lived twelve days after the attack, and on her death the extravasated blood occupied more than one-half the left lung. In a case of excessively enlarged heart, with permanent pateney of the aortic valves, the patient survived several days an effusion of blood into both lungs so considerable that they were almost disorganized.

In the *third degree* of pulmonary apoplexy the patient appears to be almost instantaneously destroyed. Dr. Fortussin, a person of strong health, but subject to hæmorrhoids, had suffered from cough with oppressed breathing. After supping off some grapes he went to bed at about half-past eleven, in a chamber next to that in which a patient lay whom Boyer had cut for the stone and confided to his care; at three in the morning the nurse went into the room and found him dead; he lay on his stomach, his left hand on his chest, and his right hand hanging out of bed; while around the bed was much blood that he had thrown up both by the mouth and nose. The body presented a violet tinge from the forehead to below the chest. He had died of apoplexy of the right lung, so considerable that its substance was ruptured in many places, and the right side of the chest filled with blood.

*Diagnosis.*—Apoplexy of the lung is distinguished from hæmoptysis by the dulness on percussion, by the "souffle tubaire," and by the subsequent fever and pnuemonia.

*Prognosis.*—Pulmonary apoplexy is always of grave prognosis; but should the patient survive the attack for a few days, and the effusion be inconsiderable and the subsequent inflammation slight, he may recover.

*Treatment.*—The treatment must of course depend on the disease being primary or symptomatic. When the apoplexy is primary, and the diagnosis can be relied on, bleeding, and perhaps to a considerable extent, together with the mineral acids or super-acid salts, appear to offer the most chances of recovery. If, on the contrary, the apoplexy be secondary, and depends on disease of the heart, the bleeding should be moderate, lest the heart be excited to a still more powerful action, and

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in this case digitalis, and perhaps some slight narcotic, should be added, to tranquillize that too highly-excited organ.

The *dietetic* and *general treatment* are the same as have been directed for hæmoptysis.

HÆMATEMESIS—GASTRORRHAGIA—

Is a discharge of blood from the stomach.

*Remote Cause.*—Hæmatemesis may result from all those causes which have been mentioned as producing hæmoptysis, but it may arise also from causes which are peculiar to the stomach, as from the effect of vomiting, or from a blow. Another peculiar cause is ulceration of the gastric artery or vein, vessels which sometimes rupture from the effects of cancer or inflammation. Frank speaks of a girl who suffered from hæmatemesis, in consequence of a small bone sticking in the coats of the stomach. In armies on actual service the thirsty soldier sometimes suffers from this affection, in consequence of drinking incautiously water containing leeches.

*Predisposing Causes.*—New-born children are sometimes subject to this disease from the day of birth till about twelve days old. Gendrin gives three cases of this kind, although there was nothing unusual in the delivery. Except at this early period hæmatemesis is rare till puberty. Frank, indeed, says he never saw this disease before puberty, nor after sixty. Both sexes are equally liable to it; but women suffer more frequently than men, and especially those who are either pregnant or labour under amenorrhœa.

*Pathology.*—On opening the stomach of a patient that has died of hæmatemesis blood is found in various degrees of consistency, or from a pure liquid black or brown blood to a solid coagulum. Portions of the blood thus extravasated are also found in the œsophagus and in the intestines. The internal surface of the stomach is almost always coated with a layer of viscid mucus which separates it from the clot. This mucus is necessarily dyed of a red colour. The quantity of blood found is very various. Dr. Elliotson saw a patient fall back and die in a minute or two with blood rushing from his mouth. On opening his stomach that organ was found distended with blood to the utmost, forming a perfect mould of the cavity. In general, the mucous membrane of the stomach is hardly stained with the colouring matter of the blood, but it is congested, and in some few spots ecchymosed—blood being infiltrated into the sub-cellular tissue. On the contrary, the surface of the mucous membrane of the intestines is almost always stained at the depending parts.

The stomach, though generally healthy, is sometimes found diseased, and the hæmatemesis is a consequence of ulceration of an artery or vein. Latour speaks of a girl who died suddenly after some fruitless attempts to vomit, and whose stomach was filled with blood, in consequence of an ulceration which had involved several vessels of the stomach. Cruveilhier gives a similar instance of ulceration of the coronary arteries; and Goëppert of ulceration of the coronary veins of the stomach. The most frequent cause of ulceration of the blood-vessels of the stomach, however, is cancer.

When hæmatemesis is symptomatic the disease found is extremely various. In one case it resulted from a schirrous tumor of the pancreas; in another from an enlarged kidney compressing the aorta; in a third from an aneurism of the cœliac artery, which, obstructing the hepatic and splenic arteries, had caused the greater portion of the blood conveyed by those arteries to pass through the gastric artery, and thus caused congestion of the mucous membrane of the stomach. Frank found in the stomach of a woman, who died of hæmatemesis at Pavia, a clot which weighed five pounds; there was no lesion of the stomach, but the liver was tuberculated and in a state of suppuration. Morgagni gives a case of hæmatemesis, in which the spleen was bigger than the liver, and weighed four pounds and a half, and Barry has given a similar case. Sometimes in symptomatic hæmatemesis the blood thrown up has come from an aneurism of the aorta bursting into the stomach; and Lieutaud gives an instance in which the blood came directly from the liver, which had adhered to the ruptured stomach.

*Symptoms.*—Hæmatemesis may be acute or chronic, the chronic form being usually termed melæna.

The acute form of hæmatemesis may be sudden in its attack, or may be preceded for a few hours by shivering, heat, weight and oppression at the epigastrium, by nausea, headache, and by pains between the shoulders. The buccal and pharyngeal membranes are also said to be sometimes congested, and the gums swollen. Gendrin likewise esteems a swollen state of the liver or spleen one of the primary symptoms, having observed those phenomena in five or six cases.

At length the hæmatemesis occurs, and a quantity of blood, black, clotted, and mixed with alimentary matters, is thrown up, sometimes streaming both from the nose and mouth. The symptoms which now follow are proportioned to the quantity of blood lost, and are nearly the same as in hæmoptysis. If the quantity be small, the pain in the epigastrium ceases, and the patient is relieved. If larger, the patient is in some degree relieved, but greatly exhausted; while, if the quantity thrown up, as it often is, be so abundant as to half fill a wash-hand basin or a chamber vessel, the patient becomes pale, a cold perspiration runs down his face, he has an overwhelming sense of sinking, and his pulse becomes frequent and weak. There are even instances in which hæmatemesis has proved suddenly fatal; for Frank relates the case of a man, aged sixty, who died suddenly and without any manifest cause, and whose stomach was found filled with an enormous quantity of blood.

It is rare that the attack terminates by one vomiting of blood. In the greater number of cases a few hours have scarcely elapsed than the epigastric and dorsal pains are renewed, the thirst and shivering return, and the vomiting recurs, often perhaps four or five times in the space of two or three days; a sensation, as of a burning liquid in the stomach, often precedes these subsequent attacks.

The symptoms which mark the recovery or else the death of the patient are the same as those which occur in hæmoptysis.

The bowels, which are ordinarily constipated previously to the hæmorrhage, generally become spontaneously open shortly after its occurrence. The stools are at first natural, but quickly become black, semi-liquid, very fœtid, and evidently contain blood mixed with bile and fæces. The abdomen is often meteorised, and the seat of painful colic.

It is supposed that hæmorrhage from the stomach may take place without vomiting, the blood passing into the duodenum, and being ejected by the intestines.

The *colour* of the blood thrown up varies according to the time it has sojourned in the stomach. If poured



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out rapidly and immediately rejected it is often arterial, but accumulated slowly it is of a blackish brown, and clotted. Sometimes a thin layer of coagulated blood forms, which when thrown up has been mistaken for a portion of the mucous membrane of the stomach.

The chronic form of hæmatemesis is termed *gastro-melæna*. In this form of the disease the blood is not poured out pure, but undergoes some change in the capillary system, so that it resembles chocolate or coffee grounds, and is, in fact, a species of black vomit. This affection usually occurs as the last stage of many diseases, especially if the patient be of a broken and worn-out constitution. The quantity thrown up is often large, amounting to a pint or two in the course of the day, and this may last for several days. When the patient falls, which is usually the case, the stomach is found congested, but without other appreciable lesion. Dr. Baillie mentions having met with a few of these cases with no very urgent symptoms, and which ultimately recovered. In this form of hæmatemesis, also, the melænic matters often pass in the stools.

*Diagnosis.*—The chief difficulty in the diagnosis of hæmatemesis is to distinguish it from hæmoptysis; but the burning heat of the stomach, the black pitchy stools, the absence of cough, and of all the signs furnished by auscultation, sufficiently distinguish it from hæmoptysis. The colour of the blood from the stomach, likewise, is generally black, while that from the lungs is more commonly arterial. The quantity is also in general greater from the former than the latter viscus, although there are many exceptions to this rule. It should be remembered, also, that blood may pass from the nose into the stomach during sleep, or from the gums after lancing. This disease is one of those, also, most easily and most commonly feigned. The matters thrown up in melæna bear no resemblance to the fluids ejected from the lungs.

*Prognosis.*—Hæmatemesis is devoid of danger when it arises from pregnancy, from amenorrhœa, and from suppressed hæmorrhoids. When, however, it arises from organic disease of the stomach, from disease of the liver, spleen, or heart, it is always of grave import, although perhaps not immediately fatal. When, also, it is the result of the action of a morbid poison, the danger is likewise often imminent. In melæna the case is always dangerous, but some few recover.

*Treatment.*—The treatment of the acute forms of hæmatemesis is similar in every respect to that of hæmoptysis, or by the bitartrate of potash, or the mineral acids. The great volume of the arteries of the stomach, and their origin almost immediately from the aorta by means of the cœliac artery, are reasons which have been alleged for this affection being but little influenced by general or local bleedings. The vast amount of blood, also, sometimes lost by hæmatemesis render it necessary to support the patient by acid wines much sooner and to a much greater extent than in hæmoptysis. In melæna the only chance for the patient is a liberal support by wine, diet, and medicines, and by opiates to quiet the stomach.

ENTERO-HÆMORRHAGE—INTESTINAL HÆMORRHAGE—

Is a hæmorrhage from some portion of the mucous membrane of the alimentary canal below the stomach. It may have its seat in the small intestines, or in the large, or in both, but probably never affects the whole length of the canal.

*Remote Cause.*—Besides the usual general causes acting upon peculiar idiosyncrasy, and also the many secondary causes, as diseases of the liver, spleen, heart, inflammation, carcinoma, or morbid poisons, there appears to be a few causes peculiar to the production of intestinal hæmorrhage, as worms; also the occasional descent of the gut, which now becoming constricted by the sphincter ani often bursts out with profuse hæmorrhage. It is said, also, that hæmorrhage from the bowels was endemic among the workmen in the mines of Anzin, in consequence of the presence of sulphuretted hydrogen.

*Predisposing Causes.*—Children are very liable to slight hæmorrhage from the bowels while teething, and at other periods of infancy. It is most common, however, in the adult, and at those periods when the party is most exposed to the action of morbid poisons, and also in advanced life, when the heart and the abdominal viscera become the seat of disease.

*Pathology.*—If the intestinal hæmorrhage be considerable, the mucous membrane is generally blanched and colourless; but, when more moderate, the point of effusion may often be determined by the mucous membrane being congested, and perhaps infiltrated at the affected portion. The mesenteric vessels are also found gorged. When the hæmorrhage takes place in dysentery the intestine is found ulcerated, and the same phenomenon is often seen in similar cases of typhus fever. The heart, liver, or spleen may be diseased, or an aneurismal or other tumor may exist.

*Symptoms.*—This affection may assume one of two forms, or that in which the blood poured out is pure; and into that in which the blood, acted upon by the capillaries, is poured out black, pitchy, and grumous, when the disease is termed entero-melæna.

The attack of entero-hæmorrhage may be sudden or be preceded by a series of preliminary symptoms, as pain in the back and loins as low down as the sacrum, and even descending down to the thighs. The patient also may suffer from colic pains, from flatulence, loss of appetite, and other symptoms of indigestion, while the bowels, also, may be either constipated or open.

Of hæmorrhage from the small intestines, Gendrin gives an instance (p. 213) of an unmarried woman, aged twenty-four, and ill of phthisis, who having for about a week experienced dull heavy pain in the loins, side, and umbilical region, with colicky pains recurring often in the twenty-four hours, passed four stools of a reddish brown liquid matter, accompanied by such weakness that she twice fainted on going to the *garde-robe*. She complained of deep-seated pain in the abdomen, and died in the course of the night. On examination tubercles were found, as had been suspected, in the lungs, but the intestinal tube was also filled with dark blood (*rouge violet*) mixed with much grumous matters. The blood was found about three feet from the stomach, and filled the rest of the intestinal canal downwards; the intestine was congested for the space of about five feet, but was in every other respect healthy.

Hæmorrhage from the large intestine is not uncommon, and is far from being attended with those grave consequences attached to that from the small intestines, although the quantity discharged is often great. From this part of the intestine the hæmorrhage is often periodical, and a great relief to persons subject to headache. It also frequently accompanies the hæmorrhoidal flux, which, as the parts are supplied by common ves-

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sels, is easily understood. There are instances, however, in which the quantity passed is so great that the patient falls into a state of complete oligamy. One man, in consequence of the descent of the gut, passed about half a pint of blood every other day for many weeks together, till he not only became sallow and dropsical, but was unable to move from his bed; still he recovered. From the general innocent tendency of hæmorrhage from these parts, it is of course intended to exclude those cases in which it proceeds from diseased heart, from dysentery, from scurvy, or from typhus, as well also as from organic disease of the intestine itself.

*Diagnosis.*—The only disease with which entero-hæmorrhage can be confounded is hæmorrhoids, and their diagnosis is rendered certain by an examination.

*Prognosis.*—Hæmorrhage from the small intestines, although not necessarily fatal, is always an unfavourable symptom. Hæmorrhage from the large intestines, if idiopathic, is of little moment; but if it be symptomatic, and results from disease of the heart or spleen, from dysentery, or from organic disease of the intestine itself, the prognosis is grave in proportion to the intractable nature of the primary affection.

*Treatment.*—Idiopathic intestinal hæmorrhage is in all cases best treated by the bitartrate of potash combined with opium, or else by the mineral acids with the same combination. When it depends, however, on descent of the gut, that part should be mechanically supported by a candle or bougie during the act of defæcation; and that this may be practicable the bowels should be kept freely open. If worms should be suspected to be the cause, the oleum terebiathinæ in ʒ ſs. doses presents the most chances of success. The treatment of those hæmorrhages which result from cancer, diseased heart, liver, or spleen, will be mentioned under the head of those disorders.

HÆMORRHOIDS.—BLEEDING PILES.—BLIND PILES.

The term hæmorrhoids is applied to certain bleeding tumors which form round the anus and lower portions of the rectum as far as the internal sphincter.

*Remote Causes.*—Hæmorrhoids are caused by everything that produces plethora of the abdominal vessels. Persons therefore who indulge largely in boiling hot tea or coffee, or who drink to excess of fermented liquors of any kind are liable to this affection. It is remarked also that hæmorrhoids affect those who ride much on horseback, as likewise pregnant women. Perhaps the most frequent cause is habitual constipation.

*Predisposing Causes.*—In a very few instances hæmorrhoids have been met with in children of six and seven years of age, but twenty to fifty-five is the more common period of life when they occur. Both sexes appear equally subject to them.

*Pathology.*—The opportunities of examining hæmorrhoidal tumors are frequent, and they are found to be both internal and external. The internal tumors or piles form between the inner sphincter and external edge of the rectum; they consist of a number of small soft hemispherical tumors of four to five lines in diameter, of a violet tint, and formed by an infiltration of blood into the sub-mucous cellular tissue. These tumors may rupture, and much blood escape from them; they also often inflame and become indurated, or else they ulcerate or form small abscesses, which, should they burst and cicatrize, are thus radically cured. The inflammation thus excited may extend to the veins which form the venous plexus of the lower part of the rectum, and these vessels, especially those that are varicose, often become impervious and obliterated. The mucous membrane of the rectum covering these tumors is, by the succession of inflammation and of sanguine infiltration into these tumors, at length rendered so vascular as to bleed on the slightest friction.

The external piles are formed by the action which the sphincter exerts over the tumors thus formed at the edge of the anus, so that at each act of defæcation they become compressed at its orifice, are pressed outwards, and are thus progressively elongated. They at length hang pendulous external to the anus, and by time they become pediculated, hard, and fibrous at their insertion.

When hæmorrhoids are complicated with prolapsus ani, the fibres of the sphincter and of the elevator ani muscles often become atrophied, wasted, and their action impaired.

In the early stages of this affection the blood or lymph effused may be absorbed, and the disease entirely subside. At a more advanced stage some become indurated and of little sensibility, while others again are soft, bleed profusely, are intensely painful, and sometimes rupture or ulcerate. The mucous membrane, which is greatly vascular, is sometimes swollen, sometimes fissured or ulcerated, and these fissures sometimes penetrate so deep as to occasion fistula.

*Symptoms.* — The hæmorrhoidal tumors produce many unpleasant symptoms, the least of which are a painful teasing action on the patient passing a stool, which is generally hard, constipated, and tinged with blood. Sometimes the hæmorrhoids are so numerous as to fill up the rectum, and should they descend so as to be grasped by the sphincter the pain is often exquisite, and the patient obliged to return the part with his finger.

When inflammation attacks the hæmorrhoidal tumors the pain is often so severe as to extend to the perinæum and testicles in the male, and to the vagina, uterus, and bladder in the female. These pains are much augmented on every motion, even by lifting up the leg, turning in bed, by sneezing or by coughing. In the worst cases every attempt at defæcation is distressing, and dreaded by the patient. Even sleep is at last almost lost, and a grave dysuria often still further adds to the torment of the patient.

The quantity of blood lost is sometimes trifling, but in severe cases it often amounts to many ounces daily. In the former instance the patient suffers little except from the local irritation; but in the latter he loses flesh, becomes exceedingly nervous, and often sinks into a state of melancholy which renders life a burthen.

*Diagnosis.*—The existence of piles, except they are excessively high in the gut, can always be determined by an examination.

*Prognosis.*—Piles have seldom any dangerous tendency unless they cause fistula; when operated on they have been known to produce accidents which have terminated fatally.

*Treatment.*—The medical treatment of hæmorrhoids consists in a few leeches to the margin of the anus, and in the exhibition of the bitartrate of potash so as to keep the bowels gently relaxed. Sulphur has been much insisted on in these cases, but Heberden says it has no greater virtue than any other laxative; Ward's paste has also much reputation.

The diet should be light, and the patient limited to



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French and Rhenish wines. It is more important, however, to induce him to abandon hot tea, or coffee, and soups. Perhaps hæmorrhoids would be little known if we drank only cold water. Ablution with cold water should be practised morning and evening; and some persons are sufficiently sthenic even to bear an injection of cold water, but much caution is necessary in the application of this remedy. If the disease resists these remedies the case becomes surgical.

### Of Apoplexy of the Liver and of the Spleen.

The liver and the spleen are occasionally the seat of apoplectic effusion into their substance, and may occasion the instant death of the party, or else the disease may become chronic; but even in this latter case the patient falls ultimately, the constitution apparently being unable to restore the parts to their healthy state. The morbid phenomena differ little from what has been described as occurring in pulmonary apoplexy, and these diseases are too rare to render them interesting to the general reader.

### Of Hæmaturia.

All those hæmorrhages in which blood is mixed with the urine, whether it proceed from the kidney, ureter, or bladder, are termed hæmaturia.

*Remote Cause.*—The usual causes of hæmorrhage all act in producing hæmaturia, but there are others peculiar to this disease, as blows on the back or loins, the existence of renal or vesical calculi; also granular degeneration of the kidney, diseases of the bladder, and some morbid poisons, as that of the small-pox or of the scurvy: cantharides and the turpentines are said to act specifically in the production of hæmaturia. A remarkable instance of the effects of the high rarefication of the air in causing this affection is, that one gentleman is said to have been seized with hæmaturia while ascending Mont Blanc.

*Predisposing Causes.*—Children seldom suffer from this affection; a girl, however, about ten years old, is now in St. Thomas's Hospital labouring under it. It is said to be more frequent among men than women; In either sex, however, it is rare, for Frank states that he saw but six cases out of 4000 patients treated at Pavia, and only one case out of 1913, which he treated in seven years at Vienna.

*Pathology.*—Hæmaturia is frequently so purely a functional disease that we are often unable to trace whether the blood has flowed from the kidney, ureter, or bladder. In some cases, however, when the hæmorrhage has taken place from the kidney a small clot remains to mark the seat of the disease; also, when it proceeds from the bladder, the coats of that viscus, though often pale, are in a few instances red, congested, and some blood exudes from them on pressure. The most usual organic diseases with which hæmaturia is complicated are, Bright's kidney, fungus hæmatodes either of the kidney or bladder, nephritic and vesical calculi, and cancer of the bladder.

*Symptoms.*—The hæmaturia may take place suddenly, or it may be preceded for a short time by pains in the loins, epigastrium, or bladder. When the hæmaturia is established the patient suffers a burning pain on passing his urine, which contains more or less blood. Sometimes the blood is deposited in clots in the bottom of the vessel, but more frequently it throws down small portions of fibrine like the sediment from beef tea. In grave cases, especially in old persons with disease of the prostate, the blood may coagulate in the bladder and render it both necessary and difficult to pass the catheter.

The hæmaturia often continues for many days, and even weeks together, and the quantity of blood passed, though often trifling, yet occasionally amounts to some ounces in the course of the twenty-four hours. The general symptoms depend, as in other hæmorrhages, on the quantity of blood lost, but, in general, the termination is a return to health. In other cases, however, the patient sinks with all his faculties about him, and in a still smaller number the fatal catastrophe is preceded by a comatose or typhoid state.

*Diagnosis.*—No certain symptom has yet been observed by which we can determine the particular seat of the hæmorrhage. We should be careful not to confound urine greatly loaded with uric acid with hæmaturia.

*Prognosis.*—Idiopathic hæmaturia is rarely a grave disease, except it arises from disease of the kidney, or carcinoma, or other structural disease of the urinary organs, when it is the precursor of a fatal event.

*Treatment.*—Idiopathic hæmorrhage often readily yields to the bitartrate of potash or to the mineral acids; two cases have lately been cured in St. Thomas's Hospital by the former remedy. Dr. Elliotson recommends the ol. terebinthinæ; other writers recommend injections of cold water, or of water in which twenty to forty grains of alum have been dissolved, into the bladder or up the rectum, and also a cold hip-bath. No remedy has yet been discovered for this complaint when it depends on structural disease of the kidney or bladder. In Bright's kidney, however, Dr. Christison recommends bleeding.

### Urethral Hæmorrhage

Is a flux of blood from the urethra.

Hæmorrhage from the urethra is common in a slight degree from an accidental blow or other violence, as the passing a bougie, but it is seldom seen as an idiopathic disease. The following case is all that perhaps is necessary to exemplify this subject.

A man, aged fifty-eight, addicted to the indulgences of the table, and who had taken long walks for five or six successive days in the month of July, was seized with dull pains of the loins, sacrum, groin, and upper part of the thighs, which he considered to be rheumatic. About three days afterwards, on passing his urine he felt a sensation of heat along the urethra, which was followed by some drops of blood, and he bled likewise during the night, but to no great extent. The next day he bled for two hours from the urethra, and lost many ounces of blood. Venesection was now performed, and he was afterwards placed in a cold hip-bath, and the bleeding was thus stopped. The next day, however, the hæmorrhage returned, but was again stopped by the same remedies.

Hoffman and other writers speak of hæmorrhage from the urethra returning periodically after the cessation of a hæmorrhoidal flux.

### Of Menorrhagia.

In menstruation the mean quantity lost, as has been stated, is about four ounces, and the time that this discharge occupies is from three to four days, so that the party loses rather more than an ounce a-day. When the menstrual discharge exceeds eight ounces in the

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whole period, the quantity is considered abnormal, and the patient is said to labour under menorrhagia. Also if the quantity be natural, but is repeated two or three times within the period, the patient is equally said to labour under menorrhagia.

*Remote Causes.*—The structure of the uterus is favourable to congestion and to hæmorrhage, for that organ is extremely vascular, and this vascularity is increased when from any cause it acquires an increased volume, as after pregnancy. Extensive venous plexuses, also proper to the neighbouring organs, and especially to the rectum, are connected with the uterus, a circumstance which greatly increases its tendency to become congested. The uterus is likewise fixed to the surrounding parts by loose cellular and other attachments, so that it is easily affected by many shocks and mechanical accidents. As the organ of reproduction, moreover, it is liable to every erotic excitement, and also to abortion, and to the accidents of parturition. Besides these, it is well known that the uterus is powerfully acted upon by every mental emotion, as well as by every ordinary physical cause, so that the exciting causes of menorrhagia are almost endless.

*Predisposing Causes.*—Lamotte speaks of having seen menorrhagia in a child seven years old. It is, however, a disease proper to adult age, and is most common between twenty-five and forty-five. It rarely occurs after the cessation of the menses, unless the uterus be affected with cancer or other structural disease.

*Pathology.*—In a large majority of cases menorrhagia occurs without any structural disease of the uterus whatever. The only change is, that the neck and orifice of the uterus are tumefied and softened, but pressure causes no pain. The orifice of the uterus is likewise open, and gives issue to the discharge; and the axis of the uterus slightly deviates forward or to the right. Hæmorrhage of course often exists with every structural disease of the uterus.

*Symptoms.*—This hæmorrhage may be sudden, but more generally it is preceded by pains in the loins and hypogastrium, aggravated by standing or walking. The patient also often suffers from a vague uneasiness, headache, flushes of the face, abdominal colic, and sometimes diarrhœa; and these symptoms do not subside on the occurrence of the menorrhagia. The hæmorrhage, if abundant, proceeds sometimes without interruption, while in other cases it occurs only at intervals, which are renewed many times in the course of the day.

The quantity of blood lost is very various, sometimes only a few ounces, while in other cases it pours from the vagina with frightful rapidity. The quality of the blood also varies greatly from the healthy secretion in its proportions of serum, of cruor, and of fibrine. In many instances it is so rich in fibrine as to coagulate in clots. In ordinary cases it scarcely coagulates, even in the vagina, and is often only slightly coloured, and these forms often alternate.

The duration of the disease is also very various; when profuse, the hæmorrhage generally begins to diminish in two or three days, and then becomes less and less for the next four or five days. Sometimes there is an alternation of increment and of decrement. In these various manners, although menorrhagia often terminates in six or eight days, yet it sometimes lasts many weeks. One of the most frequent varieties of menorrhagia is when, without being excessively profuse, the menses appear every fortnight or three weeks, and it may happen that the relapses may be still more frequent.

There is, perhaps, no example of hæmorrhage from the unimpregnated uterus terminating in death; but when the quantity lost is considerable, and in a short time, the patient is often thrown into a state of debility which lasts for years. In these cases the general symptoms are a puffed leucophlegmatic sallow face, a throbbing heart, a full quick pulse, with the *bruit du diable*, a high state of nervous excitement, and swollen œdematous legs. The local symptoms are throes like labour-pains, caused by the clots which form in the cavity of the uterus.

*Diagnosis.*—There can be no doubt that the blood in these cases flows from the uterus; and should that organ have descended and be inverted, the phenomena of menstrual hæmorrhage can be demonstrated. An examination will at once determine the seat of this disease. The violent palpitation of the heart will often lead to a belief that that organ is diseased; but the existence of the hæmorrhage, and the general absence of all *bruit*, however, will instantly remove this supposition.

*Prognosis.*—Menorrhagia, from a healthy woman, is never of grave prognosis. If profuse, however, there is danger of its laying the foundation of phthisis, or of other severe disease. Even when it results from cancer or polypus, or other disease of the uterus, the patient rarely falls from mere loss of blood.

*Treatment.*—It seldom happens, when the patient has the ordinary comforts of life, and submits to a proper dietetic treatment, that menorrhagia resists ʒj. of the bitartrate of potash every four or six hours, combined, perhaps, with half a grain of opium to each dose. The mineral acids are, perhaps, in many cases equally beneficial. The secale cornutum, by causing contraction, is certainly useful in the hæmorrhage which takes place during parturition; but the unimpregnated uterus is in a state of contraction, and the exhibition of this medicine therefore has very generally failed in cases of ordinary menorrhagia. Gendrin says he has often seen it exhibited in the hospitals in Paris in simple menorrhagia, not only without advantage, but with a manifest exasperation of the disease: "il nous a paru évident que les accidents ont été exasperés." In very obstinate dangerous cases dry cupping, a cold lavement, ice to the vulva, and compresses steeped in a solution of alum and passed up the vagina are strongly recommended.

In very chronic cases some tonic remedy should be combined with the bitartrate or the mineral acids, as the sp. ætheris nitrici ʒj. Other practitioners, however, prefer some preparation of iron, or kino, or even of quina.

The general and dietetic treatment consists in keeping the patient quiet, placing her on a hard cool bed in a well-aired room. All the fluids drank should be cold; but if she should be greatly exhausted or greatly excited, some small portion of wine may be mixed with her drink. No meat should be allowed on any pretext.

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### OF DROPSIES.—HYDROPS.—ORDER III.

DROPSY is the accumulation of a watery fluid in the serous cavities or cellular tissue of the body, constituting a class of diseases which have been treated of in the writings of Hippocrates, and subsequently in those of every school of medicine.

Dropsy may arise from a disordered action of the

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solids, or from a morbid state of the fluids. Lower appears to have been the first to demonstrate that a diseased liver or diseased heart would, by opposing an obstacle to the circulation, cause dropsy, and for this purpose he tied the vena portarum of a living dog, when the animal fell into dropsy. Dropsy, however, often exists when no obstruction can be discovered, and is evidently owing to a change in the vital affinities of the capillaries, either from mere disordered function, or else from a low inflammatory action. Besides alterations of the solids, dropsy may result from a diseased state of the fluids, and more especially when the albumen or red globules are greatly deficient; thus, in chlorosis, or after large bleedings or profuse hæmorrhage, by which the colouring matter of the blood is greatly reduced, the patient often falls into dropsy. Those states of the kidney likewise by which the serum of the blood is deprived of its albumen, also for the most part cause dropsy. The extent of the loss thus sustained may be conceived, when Andral states that in sixteen cases of dropsy he found the maximum of albumen to be only forty-eight, while the minimum was reduced as low as four, the healthy proportion being as sixty-seven. If the aqueous portion be from any cause sensibly increased, dropsy appears to be the result. Majendie, for instance, injected large portions of aqueous fluids into the veins of an animal which immediately became dropsical in all its cavities. Whatever consequently causes the suppression of a copious secretion from any membrane may be a cause of dropsy. Thus exposure to cold and wet is a very common cause; and to show that in these cases it most probably arises from suppressed perspiration, a man was varnished all over, when he is said to have fallen into dropsy. Dropsy also, it will be seen, often results from a morbid state of the fluids as from their combining with a morbid poison, as with the paludal poison, or with that of scarlet fever. It is evident, therefore, dropsy may arise from a morbid state, either of the solids or fluids, or both. The fluids effused in this disease into the various cavities of the body have been imperfectly analyzed by Dr. Marcet; they have, however, a general resemblance in whatever part of the body they may exist, but vary exceedingly in the proportions of their constituent ingredients. They are as follows:—

| In 1000 Grains of Fluid. | Specific Gravity. | Total Solid Contents. | Animal Matter. | Saline Matters. |
|---|---|---|---|---|
| | | Grains. | Grains. | Grains. |
| Fluid of Spina bifida. | 1007·0 | 11·4 | 2·2 | 9·2 |
| ,, Hydrocephalus | 1006·7 | 9·2 | 1·12 | 8·C8 |
| ,, Ascites . . | 1005·0 | 33·5 | 23·1 | 8·4 |
| ,, Ovarian dropsy | 1020·2 | .. | .. | 8·0 |
| ,, Hydrothorax | 1012·1 | 26·6 | 18·8 | 7·8 |
| ,, Hydrops pericardii . . | 1014·3 | 33·0 | 25·5 | 7·5 |
| ,, Hydrocele . . | 1024·3 | 80·0 | 71·5 | 8·5 |
| ,, A blister. . | 1024·1 | .. | .. | 8·1 |
| ,, Serum of the blood . . | 1029·5 | 1000·0 | 90·8 | 9·2 |

12,251 cases of this class of disease are reported to have died in England and Wales in 1839, or about one person in twenty-eight.

*Hydrocephalus Acutus* is an effusion of serous fluid between the membranes of the brain, or else into its ventricles.

Hydrocephalus was very little known till Dr. Whytt published his *Observations on Dropsy of the Brain*, in 1768, but since that period Dr. Fothergill, Dr. Watson, Dr. Dobson, Dr. Cheyne, and a large number of other writers have contributed to illustrate this disease. 7749 patients are said to have died from it in England and Wales in 1839.

*Remote Cause.*—The remote cause of this affection is often extremely obscure; but exposure to cold or heat, errors in diet, falls or blows on the head, the retrocession of a cutaneous eruption, or an extension of an inflammation of the ear, are among the most common. Disordered function of the liver or alimentary canal is also a frequent cause, and so is dentition, or the presence of worms; and the circumstance of a child being seized in consequence of its feet having by accident been put into a bath of boiling water, will show that any other high irritation will equally produce it. Many morbid poisons also will occasion it, as that of scarlet fever, of pertussis, or of measles; of organic diseases, tubercles of the brain are the most common exciting cause.

*Predisposing Causes.*—The epochs of infancy and childhood are the most remarkable for predisposing to this disease; for at those periods the rapid growth of the brain, the irritation of dentition, and the great susceptibility of the nervous system generally, are all powerful causes of determination of blood to the head. The greatest number of attacks, according to Percival and Brichtean, occur between the second and the fifth year; or, as a more general law, it occurs from the infant at the breast to twelve years old. Children with large heads and precocious intellects, and more especially those of a scrofulous diathesis, are its most frequent victims. One warning may be learnt from this disease; that it is most common in the children of parents addicted to drunkenness, and from this cause it often runs in families.

*Pathology.*—There are a few cases in which effusion of serum into the ventricles, or into the cavity of the arachnoid, is unaccompanied by any morbid appearance of the brain or of its membranes whatever, so that hydrocephalus is essentially a mere functional disease. More commonly, however, some lesion of the brain or its membranes does exist; thus the substance of the brain is often marked with more bloody points than usual; the septum lucidum, the fornix, and other parts forming the walls of the ventricles, are often found in a state of softening, sometimes so soft that Golis gives a case in which water could be expressed from it as from a sponge. The membranes also are sometimes found congested, or opaque and thickened, with spots of lymph, evidently the effect of a low inflammation.

The quantity of fluid effused varies from a few teaspoonfuls to seven or eight ounces; and of this the greatest part is generally contained in the lateral ventricles, which from this cause are often so enlarged and distended that the finger placed on the brain immediately over the ventricle is sensible of a distinct fluctuation, while the anterior portion of the fornix is often so raised as to cause a free communication with the third ventricle, and, perhaps, with the fourth, at least the effused fluid is found likewise distending those cavities. The quantity of fluid effused between the membranes is also often great, sometimes filling the whole cavity of the arachnoid as well as the ventricles. Dr. Abercrombie has found serum effused even between the cranium and dura

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mater, and so also have Bonet and Guding, a circumstance hardly known in any other disease. The choroid plexus or ventricular membrane, although in general pale and healthy, yet sometimes has the intercellular tissue so infiltrated that it is studded with small cysts like a bunch of currants.

The more frequent accidental occurrences are tubercles in the brain or membranes, and some congestion, perhaps, of the mucous membrane of the intestinal canal; but whether the latter is a primary affection or the result of the violent medicines which are generally had recourse to in this affection is not determined. Dr. Joy has remarked that the peculiar green colour of the stools was imparted in the lower portion of the intestine, the fæcal contents of the upper portion being of a pale drab colour, while the bile in the gall-bladder was of a yellow colour.

The pathology of this disease explains no phrenological fact. The child is highly irritable, peevish, and fretful; so if any conclusion is to be drawn, it must be that there is a connexion between the ventricles and the passions.

*Symptoms.*—Authors have greatly differed as to the nature of this disease, some considering it a mere dropsy, while others have as constantly referred it to an inflammatory origin, but they have generally concurred in dividing it into acute and chronic.

Acute hydrocephalus is divided into three stages; the first stage, according to Dr. Cheyne, being that of increased irritability; the second, that of diminished sensibility; and the third, that of convulsions or palsy.

The first stage may be either sudden in its attack, or be preceded several days by giddiness, so that the child stumbles or falls at play; by a furred tongue, constipated bowels, and, perhaps, offensive breath. At length the senses of sight and of hearing become morbidly acute; he starts at slight noises—complains of intermitting headache—rests his head on his nurse's lap—cries, "Oh! my head, my head!" and then after a time rises up and plays again. As this stage advances the pulse rises, the skin is hot and dry, the urine scanty, the stomach irritable, the bowels constipated, perhaps painful, the stools black and offensive, while the brow is knit, and the pupil of the eye contracted or expanded. The most remarkable feature, however, is a great fretfulness of temper, so that the child is not merely pettish, but quarrelsome. If he sleeps his sleep is short, uneasy, moaning; he also grinds his teeth, rolls his head, and when he wakes up it is with a scream. To sum up the phenomena of this stage in the language of Dr. Cheyne, "We are led to suspect some deeply-seated evil from the frantic screams and complaints of the head and belly, alternating with stupor, or rather lowness, and unwillingness to be roused."

The second stage commences when effusion has taken place; and now the pulse, instead of being rapid, is as slow, perhaps slower than natural, but this is chiefly when the patient is in a horizontal position, for if he attempts to sit up it again becomes rapid; the sickness is also abated; nevertheless the child lies in a state of stupor and of great unwillingness to be moved, with his eyes half-closed, dull and heavy, or else staring or squinting, the pupil being still contracted or expanded, and he often suffers from double vision. The stupor, however, is still interrupted by exclamations or shrill piercing screams, while the tremulous hand of the little sufferer is incessantly engaged in picking his nose or mouth.

In the third stage the patient either sinks or else recovers. If the event is unfavourable the pulse again rises, the eye becomes red and dim, and the child, delirious, is often attacked by partial or general convulsions, or else one limb or one side may be palsied. From this point the powers of life gradually sink, till at last death closes the affecting scene. If the patient should fortunately recover, the stupor subsides, the countenance becomes more natural, the bowels more regular, the secretion of urine perfectly restored, and at length his health, though long broken, is gradually re-established.

The duration of this disease is estimated at about three weeks, each stage averaging about a week.

*Diagnosis.*—Hydrocephalus is distinguished from typhus by the screaming, rolling of the head, grinding of the teeth, and by the absence of the peculiar tongue which marks the latter disease.

*Prognosis.*—The chances of recovery in the first stage are very many if the patient be properly treated. At any subsequent period the prognosis is most unfavourable, and Dr. Cheyne estimates the loss of confirmed hydrocephalus at six to one, and perhaps this is near the truth.

*Treatment.*—This disease is only successfully combated in the first stage; and the first thing to be done is to purge the patient. The purgative is not of great moment, provided it acts freely. Some prefer gamboge, grs. v. 6$^{ts}$; others, calomel grs. ij. to grs. v., with jalap or scammony grs. x. to grs. xv., or the same quantity of the extracti colocynthidis comp.; and this dose is to be followed up by a black draught, or the sulphate of magnesiæ. The stools are generally black, or extremely offensive; and this state of the bowels corrected, the disease, if sympathetic, often ceases. If, however, the head be not relieved, some leeches should be applied to the temples, and the head should be shaved and surrounded with some cold evaporating wash, as with a towel dipped in cold spring water, or in vinegar and water, &c.

If the disease be further advanced, no efficient treatment has as yet been determined. Many practitioners have attempted the cure by copious bleedings, but the symptoms do not yield to the lancet like those of simple inflammation. Mercury has also been used to a great extent, but with little success. In urgent cases, for instance, mercury has been rubbed on the back and thighs, even in very young children, to the extent of half a drachm to ʒ j. three or four times in the twenty-four hours. Calomel also has been rubbed on the gums to the extent of three or four grains every four or five hours; and it has likewise been given by the mouth in doses of two grains every third or fourth hour. Mercury given in these large doses, it must be remarked, seldom produces salivation; for Dr. Clarke says he never saw that effect in children under three years of age, except in three cases; but it is not successful, and more generally produces *spinage* stools, irritates the alimentary canal, and perhaps does harm. In France the mercurial treatment has been so unsuccessful that some practitioners have even tried a most opposite remedy, or quina, but the result has been equally fatal. Blisters, moxas, and other modes of cauterization have been used as auxiliary treatment, but without apparent benefit.

*Dietetic Treatment.*—During the whole course of this disease the treatment should be slops and light puddings.

*Hydrocephalus Chronicus.*—This affection may be congenital, caused by some disease or else defective development of the brain during fœtal life, or it may occur at some period in after-life as an original disease.

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*Remote Cause.*—The remote causes are little understood, but as far as they are known they are similar to those producing hydrocephalus acutus.

*Predisposing Causes.*—This disease, it has been stated, may occur during fœtal life, but is more common in the early periods of infancy and childhood. Adult age is not altogether free from it, and Golis has mentioned three cases of persons attacked in old age, two of whom were above seventy, while the other, perhaps less advanced in life, suffered from this affection for ten years. It seems sometimes to run in families; at least Frank mentions a family of seven children, all of whom were born with this disease; and Golis, another, in which six children were aborted hydrocephalic at six months; while three others, born at the full period, were attacked shortly after birth. The sexes appear to be equally liable to it, or nearly so, as 4313 males and 3436 females died of it in 1839.

*Pathology.*—The first thing that strikes us on examining these patients is the enormous *size* of the head. The adult head averages about twenty-two inches in circumference; but there was in St. Thomas's Hospital a child, Elizabeth Phillips, whose head measured, at eleven months old, twenty-seven inches and five-eighths; while Dr. Bacon* gives the case of a child whose head at three months had attained the enormous size of twenty-nine inches in circumference. The head of Cardinal, also a celebrated hydrocephalic man, long in St. Thomas's Hospital, and who afterwards died at Guy's, measured thirty-three inches and a half. There are instances, however, in which the cranium has been found unusually small, and of a conical shape, the sutures being closed before birth, and in this case the child is still-born, or dies shortly after delivery. When the disease comes on at later periods of life, and after the sutures are closed, the size of the skull is natural.

The *form* of the hydrocephalic head is also sometimes very irregular, one side being much larger than the other, while the base of the orbits is for the most part convex instead of concave, thrusting the eye unnaturally forwards. On cutting through the skull the bones are found to be remarkably thin and transparent. The sutures also, although generally closed towards the base of the skull, are commonly separated from each other by a wide extent of membrane at their superior portions. If, however, the patient should survive for several years, the membranous portion becomes ossified by a number of points forming "ossa wormiana," and the sutures are thus partially closed. In some very few instances the sutures not only close, but the bones of the skull have a morbid thickness, which thick and large skulls, Dr. Joy conceives, on being dug up have been mistaken for those of giants.

The membranes of the brain are generally thickened, and the water found effused either into the cavity of the arachnoid, into a cyst, or into the ventricles of the brain. When the water is contained within the cavity of the arachnoid, the brain is sometimes so compressed that there are instances in which hardly a vestige of that organ remains. A singular and rare variety of this affection is, that the arachnoid sometimes protrudes through the fontanelle or open suture, and the dura mater and integuments yielding, a pyramidal bag with its apex downwards forms externally, which hangs low down the back like a jelly-bag.

* *Med. Chir. Trans.*, vol. viii.

When the effused fluid is contained in the ventricles, those cavities are found exceedingly dilated. The convolutions have no depressions, but appear unfolded. The corpus callosum is much raised, the septum lucidum is torn and destroyed, so that the ventricles communicate. The parts at the base of the brain also, as the corpora striata and thalami opticorum, have scarcely any existence. In fact, the brain seems expanded into a large sac, in which the medullary and cortical substance are so confounded as to be undistinguishable. In Dr. Bacon's case the brain and membranes, even the dura mater, had ruptured, and a probe passed easily through the ethmoid bone into the nose, by whose orifices a considerable dribbling of the fluid took place during life. Golis met with a case in which the water was contained in a cyst the size of a goose's egg, situated between the hemispheres of the brain of a child aged six years, and who died, the cyst being entire.

The quantity of fluid contained in the cranium in hydrocephalus chronicus varies from a few ounces to a few pounds. In the case of Cardinal it was found to exceed ten pints, or nine pints in the cavity of the arachnoid and one pint in the ventricles. Other cases have been, however, recorded in which the quantity has amounted to twenty pints.

*Symptoms.*—There are two forms of chronic hydrocephalus, the internal and the external or jelly-bag hydrocephalus. In either case, when this disease is fully formed, whether it be congenital or subsequent to birth, the child is generally of most feeble intellect, irascible, often epileptic, and of extreme muscular debility, so that if not palsied he is hardly able to walk. Dr. Baillie met with an instance of chronic hydrocephalus in a man aged fifty-six, and whose ventricles contained six ounces of serous fluid, and his chief symptoms were pain in the head, and a loss of memory so great that he could recollect only five words, which he continually reiterated to express all his wants. Cardinal, whose case has been mentioned, had more memory, and he prided himself, says Dr. Elliotson, in being able to say "The Belief," but he usually stumbled when he got to Pontius Pilate. This man was epileptic, of very feeble intellect, and so irascible as to be always quarrelling with the patients, and would have been extremely difficult to manage except for his muscular debility. Heberden, however, mentions a case in which eight ounces of water were found in the ventricles, and yet no symptoms of hydrocephalus existed during life.

*Diagnosis.*—The external characters of chronic hydrocephalus are so extremely marked that it is hardly possible to mistake them.

*Prognosis.*—The immediate danger in these cases is not great, but few patients survive the age of puberty; Cardinal, however, lived to the age of thirty-two. Aurival speaks of another instance which reached forty-five; and Gall of a third who survived till fifty-four.

*Treatment.*—In congenital hydrocephalus the unassisted efforts of nature seem incapable of effecting a cure; and it is extremely problematical if medicine has been of any use. When, however, the case is pronounced hopeless, the propriety of evacuating the water by means of an operation may be entertained. Golis has given the names of twenty-seven writers who have expressed themselves in favour of it, especially if the fluid be slowly evacuated, and at several repetitions of the operation; yet he himself, along with seven or eight

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others, including Boerhaave, proscribe it altogether as cruel and useless; however, it has been successful.

When the operation is performed, it seems an axiom that the fluid should be allowed to escape gradually, for otherwise extreme faintness and collapse may be expected. In such case small doses of ammonia, or a few tea-spoonfuls of brandy and water shortly revive the little patient. Should, however, at a subsequent period, re-action take place, a few leeches and a cold lotion ought to be applied to the head.

It seems also determined, that the younger the child the more chances of success; for if it lives a few years, the sutures of the cranium, though open at the top, are united by bone towards the base of the skull, and thus present a mechanical obstacle to the closing of the sutures, and consequently the operation must fail.

If this disease should occur in after-life, blisters and mercury to salivation are the remedies most relied on.

*Hydrorachis*, spina bifida, or dropsy of the Spine, is an excess of serous fluid in the cavity of the Spine. This is, for the most part, a congenital disease, and, in its rarest forms, the fœtus is born without a spinal cord, the membranes forming a sac filled with fluid. In other cases the axis of the spinal cord is open, as in fœtal life, and filled with fluid; while in others the spinal cord is perfectly formed, only compressed by the quantity of water by which it is surrounded. In the more usual form of the disease there is found one, more rarely two, external swellings, containing fluid. The form of these watery tumors is flat, semilunar, or pyramidal. They are formed by the expanded membranes of the cord, covered with the common integuments. The cleft by which they communicate with the spinal cavity varies greatly, and usually results from one or more vertebræ being defective; in rarer cases, by a round aperture in one of the vertebræ, and still less frequently by a similar aperture between an intervertebral space. The symptoms of hydrorachis are debility, emaciation, and very generally palsy, as well as anæsthesia of the lower extremities, resolution of the sphincters, inability to take the breast, and convulsions. The life of the child usually terminates at birth, or shortly after; but in some few instances the party attains a greater age. Paletta met with one patient seventeen years old; Henderson saw another at eighteen; Warner, one at twenty; Camper, one at twenty-eight; and Cowper, one that survived till thirty. Dr. Copland, in 1822, saw a young woman aged seventeen, who, in addition to the singularity of hydrorachis, menstruated regularly from two ulcers in the thighs. The tumor in this case measured thirty inches in circumference, and she passed her fæces involuntarily. She was in good health at this period, but died a few months afterwards. No efficient treatment, perhaps, exists for this disease.

### Dropsy of the Organs of Respiration.

*Angina Œdematosa*—Œdema of the Glottis—Hydro-glottis—is an effusion of serous fluid around and into the lips of the glottis.

*Remote Cause*.—This disease is occasionally idiopathic; often preceded by other forms of dropsy; and it is also in some instances the result of inflammation. When this form of angina is idiopathic, it probably most often results from cold or wet; when t is preceded by other forms of dropsy, those dropsies are usually caused by the poison of scarlet fever, or of the paludal fever.

*Predisposing Causes*.—When œdema of the glottis is idiopathic, it has occurred most frequently in the adult between fifty and sixty. When preceded by other dropsies, it is most common in early adult age; and when it results from inflammation, most usual in children.

*Pathology*.—In these cases the loose sub-mucous cellular tissue of these parts is seen distended with a colourless serous fluid, sometimes merely closing the lips of the glottis, but at other times swelling out as big as an egg. If the disease be idiopathic, or the termination of dropsy, no redness is present. If, however, it is the result of inflammation, the quantity of fluid effused is less, but the tissues are red, injected, thickened, and easily torn.

*Symptoms*.—This disease, if idiopathic, or caused by dropsy, is usually sudden in its attack, the patient being seized most unexpectedly with a difficulty of breathing and a sense of suffocation, which shortly arises to orthopnœa. The head is now thrown backwards, the countenance becomes purple, the hand of death is on the patient, and for the most part he dies in a few minutes suffocated.

*Diagnosis*.—Œdema of the glottis is distinguished from œdema of the lung by the chest being perfectly sonorous.

*Prognosis*.—The prognosis is, in every case, most unfavourable.

*Treatment*.—The treatment of this disease is necessarily energetic, and the two following cases will exemplify this axiom. Two patients, both of them females, about forty, were brought on the same day to St. Thomas's Hospital, and as nearly as possible in the same state of idiopathic œdema of the glottis. They had been ill a very few days, and they now suffered from loud croupy breathing, orthopnœa, purple lips, and the other symptoms which have been described, but otherwise they had not suffered greatly in health. One was bled and blistered; the other was bled, blistered, and took mercury so as to affect the mouth. The latter recovered, while the former died. On examination, the cartilages of the larynx were ossified, but the cause of death was simple œdema of the glottis. In extreme cases it is, perhaps, right to perform tracheotomy.

*Œdema of the Lungs*—Hydro-pulmonalis—is an effusion of water or serum into the cellular tissue of the lungs. Laënnec says this disease, though common at the time he wrote, was nevertheless very little known. He thinks Albertini and Barrère, of the military hospital at Perpignan, first described it in 1753, but failed in attracting the attention of the profession to it.

Œdema of the lung is, in a very few instances, a primary disease. More commonly it occurs at the close of other dropsies, and in some few instances results from inflammation: its remote and predisposing causes are little known.

*Pathology*.—On opening the body in these cases the lung not only does not collapse, but bears the impress of the rib; and if the finger be forcibly placed on it, the impression remains. If the lung be now cut into, a colourless transparent serum flows from it; but its structure is healthy, although often of a pale yellow or greenish colour, being stained by the effused fluid. The accidental conditions are bronchitis and pneumonia, in the first or second degree, and diseased states of the heart.



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*Symptoms.*—The symptoms which denote this affection are a sudden and great difficulty of breathing, incapability of lying down, cough, with a more than usual fluid expectoration. The face also is livid, and the pulse rapid.

If the effusion be considerable, the respiration is loud and tracheal, while a dull sound is returned all over the chest. If of less amount, the *râle* is subcrepitant, while sufficient air penetrates the lung for the chest to return a natural sound.

*Diagnosis.*—This disease is to be distinguished from hydrothorax, and the diagnosis is difficult; but the change of position does not so distressingly and immediately affect the patient's breathing in this disease, the water more slowly gravitating towards the root of the lung. The phenomena of ægophony are also wanting in this affection.

The *Prognosis* is always most unfavourable, and the patient seldom survives more than a few hours.

*Treatment.*—If this disease is ever idiopathic, it probably must destroy the patient even before our most active remedies can act upon the system; but the only chance for the patient must be energetically to use perhaps mercury and the bitartrate of potash.

*Hydrothorax* is the effusion of water into the cavity of the chest, and was a disease known to Hippocrates, who proposes the singular practice of shaking the patient, in order to determine the existence of the disease. 2149 cases are said to have died of this disease in England and Wales in 1839.

*Remote Cause.*—Hydrothorax is occasionally a primary idiopathic disease, and is the result of all the usual causes of dropsy, as cold, wet, or intemperance. In other cases it results from disease of the heart, liver, or other causes obstructing the circulation. Inflammation of the pleura is also a cause; and often results from the action of a morbid poison, as the paludal poison, or that of scarlet fever.

*Predisposing Cause.*—Hydrothorax is infrequent in children, and not common till after the age of forty, when the viscera become disorganized, and low inflammations are readily set up. It occurs in both sexes in the ratio of 1199 males to 950 females, or as ten to twelve nearly.

*Pathology.*—In idiopathic hydrothorax, the chest, on being opened, is found more or less full of water, which being removed, the pleura is seen sometimes healthy, but more generally of a dark colour, a quantity of venous blood being congested in the vessels from deficient oxygenation. The fluid may be effused into one or into both cavities of the chest. It may also be limpid and colourless, like water; but more commonly, perhaps, it is citron-coloured, and contains much albumen. The quantity effused varies from a few ounces to many pints: eight and nine pints are not unusual; and Laënnec states that he once removed twelve pints from the right side of the pleural cavity. When the quantity of fluid is large, the lung is thrust up under the sternum, and so compressed as to be sometimes no bigger than the fist.

When hydrothorax is secondary, almost every chronic affection, either of the liver, kidney, or heart, may be found co-existing at the same time. Occasionally it is the result of pleuritis, and in these cases the serum is more flocculent, contains more albumen, and portions of lymph are often also seen adherent to the pleura pulmonalis, or pleura costalis: the two pleuræ are also often more or less united.

*Symptoms.*—The effusion may take place either gradually or suddenly. In the former case it may be so slow that the lung is able to adapt itself to the presence of the accumulating fluid, and the symptoms will consequently be much less marked, although the effusion be large. In the latter case the functions of the lung are almost at once suspended, the countenance livid, the breathing greatly disturbed, and the patient perhaps has hardly time to rush from his bed before he expires in the paroxysm.

When the effusion is slow, the symptoms are difficulty of respiration, which is carried on rather by the shoulders and diaphragm than by the intercostal muscles, some expectoration, lividity of the face or lip, œdema of the legs, and either a very full labouring pulse, or else one that is small, frequent, and intermitting: the urine also is extremely scanty. As long as the effusion is moderate, the patient is unable to lie down, from the sense of suffocation produced by the fluid gravitating towards the root of the lung, and compressing the larger bronchi, and he therefore sits propped up by pillows, with his head bowed forwards. In the event, however, of the effusion being so considerable that the function of the lung is entirely suspended, the patient can lie flat in his bed without experiencing any inconvenience.

When the effusion is sudden and of some amount, and the patient survives the first attack, the dyspnœa is liable to severe exacerbations, and is well represented by Dr. Darwell (*Encyclopædia of Medicine*):—"in a tray-painter these paroxysms came on every morning between two and three o'clock, and lasted for an hour or more. This man was compelled, by a sense of suffocation, to start out of bed, and while the attack lasted he placed himself against an open window, gasping in the most terrific manner for air. His death took place suddenly, and on examination the lungs were found to be œdematous. Upwards of two quarts of serum were contained in the cavities of the pleuræ, and a few ounces of coffee-coloured fluid in the pericardium. The only other morbid appearance in the whole body was hypertrophy of the left ventricle.

When hydrothorax is symptomatic, or consecutive of affection of the heart or of other disease, it is generally preceded by swelling of the legs or eye-lids,—by the urine being plentiful and albuminous, or else scanty, high coloured, and loaded with the usual salts,—and indeed by most of the symptoms of dropsy generally. In these cases the effusion seldom takes place into the chest till a few days before death, rendering the agony doubly painful and suffocating.

When the effusion is moderate, auscultation gives bronchial respiration, some mucous rhoncus, and also bronchophony, and occasionally that undetermined condition called ægophony, which is a broken sound like the bleating of a goat, or the amusing notes used in the exhibition of Punch, and which is heard as though the patient was speaking at the end of the stethoscope, but not through it. This singular phenomenon is heard only in the back, and when the instrument is placed, as is supposed, about the level of the effused fluid. When the effusion is more considerable, the respiration is almost tracheal,—there is neither bronchophony nor ægophony, and a dull sound is returned over a greater part of the chest. Again, if the patient's chest be bared, there is no expansion on the side of the seat of the effusion, the respiration of that part being carried on altogether by the shoulders and diaphragm; and should the effusion be

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Elementary Principles of Medicine.

excessive, the affected side bulges out, as in empyema, and its intercostal spaces are enlarged and prominent.

*Diagnosis.*—The absence of pain, and of the other symptoms of inflammation, distinguish this disease from acute pleurisy. Should, however, the pleurisy be chronic it is impossible to distinguish the two diseases, except by the previous history. The diagnosis also between hydrothorax and œdema of the lung is, as has been stated, most difficult.

*Prognosis.*—Some cases recover from hydrothorax, but they are few, so that the prognosis is in all cases extremely grave and unfavourable.

*Treatment.*—The treatment of hydrothorax is of great difficulty, from the many causes on which it may depend, and also from the almost uniformly intractable nature of the disease. As a general principle, mercury combined with squills, digitalis, or the bitartrate of potash, and pushed so as to affect the mouth, is among the most valuable of our remedies. It is much more efficacious in this form of dropsy than in ascites, and it is remarkable in many cases to observe how immediately the symptoms are arrested as soon as the gums are touched. Should this treatment fail, we must have recourse to gamboge or to other purgatives or diuretics, and of these some one perhaps may be found to succeed, yet much more commonly they all fail. With respect to bleeding, it seems only admissible in two cases, and then only to a moderate amount, as when hydrothorax supervenes on pleurisy or on disease of the heart with expectoration of blood. The general want of success attending the treatment of hydrothorax has induced some practitioners to propose the operation of paracentesis of the chest. It is questionable whether any case is on record of a successful result of paracentesis in cases of idiopathic hydrothorax; but there seems no reasonable objection to the operation when all other methods are hopeless. It should be borne in mind, however, that both sides in all probability must be tapped,—that the operation is not without danger, both from the wound and from the admission of air into the cavity of the pleura; also, that it has no power to remove the hydropic diathesis; and, lastly, that it is extremely likely the disease may co-exist with œdema of the substance of the lung.

### Hydrops Pericardii.

Hydrops pericardii is a collection of water in the pericardium.

*Remote Cause.*—Hydrops pericardii occurs in a few instances as an idiopathic disease, and probably results from the causes of dropsy in general; more commonly it results from inflammation, and that inflammation may be caused by rheumatism, by the paludal poison, or by the poison of scarlatina. In other cases it is only the last stage of some other form of dropsy.

*Predisposing Causes.*—When hydrops pericardii is idiopathic, it usually occurs before the age of puberty; when caused by a morbid poison, it is more common in adult age; and when from previously existing disease, it occurs chiefly between 40 and 60. Both sexes are liable to this disease, and perhaps in nearly equal proportions.

*Pathology.*—In hydrops pericardii there is no alteration of structure, says Laënnec, of the heart or of its membranes. Some authors have stated that the heart is macerated in these cases; but such writers, he adds, must have badly observed, and still worse expressed, what they have seen. When it is the result of inflammation, the usual appearances of pericarditis are found. The fluid contained in the pericardium is usually limpid, without any flakes of albumen. Most commonly it is colourless, but occasionally it is of a citron or red hue, from containing a small portion of the red particles of the blood. Its quantity is very various; sometimes a few ounces, sometimes two or three pints; while Corvisart states that he met with one case in which it amounted to eight pints. The smallest of these quantities is in great excess, for Dr. Darwell has given the results of the examination of 150 bodies, dead of all diseases, and he found that in 30 only out of that large number was there any appreciable quantity of fluid found in that cavity. It seems probable, therefore, that during life the secretions of the pericardium exist only in a state of vapour.

*Symptoms.*—If we consult those authors who have treated on dropsy of the pericardium, we find little agreement among them of the pathognomic signs of this disorder. Lancisi considers the leading symptom to be the sensation of an enormous weight in the præcordial region. Reimann and Saxonia assure us that the patient feels his heart swimming in a great quantity of fluid. Senac has seen, in the third, fourth, and fifth intercostal spaces, the waves of the effused fluid; and Corvisart says he has felt them. The latter physician adds to this symptom a sense of weight at the heart—a greater dulness on percussion; a pulse small, irregular, and frequent; together with a tumultuous but obscure action of the heart, as if it moved in a larger circle. He speaks also of frequent syncope,—of general œdema,—and of the patient being unable to lie down in bed. Rostan is so dissatisfied with all that has hitherto been observed respecting the diagnostic symptoms in this disease, that he affirms it can only be determined by a process of negation, or, that when we are unable to refer the existing symptoms to any other assignable cause, we may infer that they can be owing to no other circumstance than water in the pericardium. A youth, about 15, was admitted some years ago into St. Thomas's Hospital labouring, as was supposed, under a slow fever. The fever subsided, when he suffered much from cough and affection of the chest. It was not phthisis, for he did not expectorate; it was not hydrothorax, for he could lie down; and it was not pneumonia or pleurisy, for there was no pain or other symptom of these disorders. It was therefore inferred it was water in the pericardium; and, on laying the hand on the cardiac region, the heart was found to be beating feebly but rapidly, and on spanning the limits of its apparent action, it was found moving in a space of several inches. The diagnosis was consequently water in the pericardium; and on examining the poor lad, who died some weeks after, three to four pints of fluid were found in the pericardium, without any other existing disease.

Laënnec says he has had but few opportunities of observing dropsy of the pericardium, and is doubtful if the stethoscope would be useful in determining the disease. He thinks percussion and inspection would not detect less than a pint; but should the water exceed two pints, he thinks these means would determine it.

*Diagnosis.*—The difficulties attending this question have been already stated; and these difficulties are increased by the fact, that effusion into the pericardium was found by Chossat in all the animals killed by him in his experiments on inanition. Consequently a similar effusion in all probability takes place in many chronic diseases when the agony has been long, and is one of the last phenomena of waning life.



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*Prognosis.*—Always most unfavourable.

*Treatment.*—Laënnec thinks we may cease to regret our imperfect knowledge of the symptoms of hydrops pericardii on account of the few resources we possess for the cure of this malady; for mercury, digitalis, the bitartrete of potash, as well as every other class of medicines, have been found powerless against it. Under these circumstances paraceutesis has been recommended; and if performed, Laënnec advises trephining the steroum above the ensiform cartilage, which would enable us to see and touch the pericardium, and even to inject a fluid, if thought advisable.

Ascites—(ασκος, a bladder)—

Is a collection of serous fluid in the cavity of the abdomen. Only 120 deaths are recorded to have died of this disease in England and Wales in 1839; but 12,251 are stated to have died of dropsy of uncertain seat, and a large proportion of these must have contained water in the abdomen.

*Remote Cause.*—The remote causes of this form of dropsy are the same as those of dropsy of the chest; but those causes act more energetically on the peritoneum than on the pleura. Ascites, for example, is more frequently produced by large bleedings, by phthisis, and by disease of the heart or kidney, than hydrothorax. Tumors, also, obstructing the circulation, are more frequent in the cavity of the abdomen than of the chest. Changes of temperature, morbid poisons, a diseased state of the intestines, or of the liver, or of the spleen, are also causes which act more frequently in the production of ascites than of hydrothorax. In the female, also, many peculiar causes are in action to produce ascites: thus ascites sometimes follows parturition. Two cases of ascites were lately in St. Thomas's Hospital from the parties wearing large pessaries. Ovarian dropsy also frequently terminates in ascites.

*Predisposing Causes.*—Every age is liable to ascites, from the infant at the breast to the extremest period of decrepitude; in generel, however, ascites is rare before puberty. The largest class of ascites, or that arising from disease of the kidney, takes place between 20 and 45; the next largest class, or that from disease of the liver or the heart, occurs most frequently from 40 to 60. Both sexes are liable to ascites, and apparently in nearly equal proportions.

*Pathology.*—Cases of ascites are often examined in which no affection of the peritoneum or of any organ or tissue can be discovered, and consequently it is essentially only a disease of function. More commonly, however, the peritoneum is either chronically or acutely affected, or some viscus is diseased, or some tumor presses on the large vessels, and causes the effusion which constitutes the ascites.

When the peritoneum is chronically affected, it becomes thickened, opaque, and, in some cases, of an aponeurotic whiteness. In general the portions covering the liver or the spleen are much the most thickened and diseased, owing probably to primary disease of those organs having extended to their peritoneal covering; on the contrary, if the peritoneum be acutely inflamed, it is red and injected, and more readily detached from the walls of the abdomen than in health: it may also be tuberculated, or the seat of other disease.

The kidney is the organ most frequently affected when the ascites is secondary: indeed the number of cases of this form of dropsy amount, according to Dr. Wells, to 55 per cent. of the whole number treated, and according to Dr. Christison, to 75 per cent. The kidney is found in this affection in every possible state of disease,—that is, it may be atrophied, hypertrophied, encysted, tuberculated, or cancerous; but in the vast majority of cases it is found in that peculiar state of degenerescence usually termed Bright's kidney, and in every stage incident to that disorder.

The next most frequent concomitant affection is disease of the heart and large blood-vessels, to which it is supposed that at least one-fourth of all the cases of ascites is owing. In these cases the cavities of the heart are often enlarged, and their walls either hypertrophied or atrophied, or else the valves are ossified, or their action otherwise impeded. The aorta also is often pouchy, and its elasticity destroyed by ossific deposit or other affection.

The liver and spleen are the organs next most frequently affected; and they may be found in every possible state and stage of disease. In the former of these instances it is generally supposed that the dropsy is owing to the obliteration of the capillary vessels; looking, however, to the thickened state of the peritoneum covering the liver, it seems that sympathetic irritation of that membrane must at least often contribute to the production of ascites. No satisfactory theory has yet been proposed for ascites resulting from diseased spleen; but looking to the excessive hæmorrhage, which often terminates the life of the patient in these cases, it seems probable that it must in some measure depend on an altered state of the blood.

In general anasarca accompanies ascites, and is an abnormal collection of serum in the cellular tissue of the lower extremities or other part of the body. In these cases the cellular tissue is found in very varied states: in some cases the cells are greatly enlarged, in others obliterated; while the tissue itself, generally thickened, tears most readily in some cases, while in others it is not only greatly thickened, but also greatly indurated. The fluid also which it contains is generally limpid and watery, holding in solution a large portion of albumen, and probably of urea, while in other instances the fluid is viscid and contains lymph.

The quantity of fluid contained in the abdomen varies from a few ounces to many gallons; three to four gallons are by no means unusual, and as much as eighteen gallons are said to have been drawn off at one time by the operation of paracentesis. The quality of this fluid is very various. In colour it is generally green or yellow, in consistency viscid, often containing so much free albumen as to be incapable of flowing through the canula. When treated with nitric acid that substance is thrown down so abundantly as to form a jelly, or a still more solid mass. In other cases it is mixed with lymph; and, in a few instances, contains a large number of hydatids. When the urine is scanty the effused fluid contains urea, and also the usual salts of the blood.

*Symptoms.*—The symptoms of ascites are extremely well marked, but vary in some degree according to the cause, so that it will be better to give first a general outline of its more prominent features, and afterwards to point out those particular symptoms which denote the cause from which it springs.

In ascites, if the quantity of fluid effused be considerable, the abdomen is distended and shining, with a number of large superficial veins creeping over its surface. From the weight of the abdomen the gait of

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the patient is upright like a pregnant woman, and he walks wide between the legs from anasarca. In bed he is unable to lie down on account of the fluid in the abdomen gravitating towards the chest and compressing the lungs, so that he is obliged to be assisted by the dropsy-bed. If the anasarca be limited to the lower extremities the upper portion of his person is in general greatly emaciated, and his sharp and pinched features and his withered arms form a striking contrast to his protuberant abdomen and swollen legs. On the contrary, if the anasarca be general, the trunk, the arms, the hands, the eye-lids, and face generally are tumid and swollen to a most unsightly degree. In one case now in St. Thomas's, the features of the patient are lost in the general œdema, while from the pressure of some enlarged glands of the neck those parts of the cheek which are usually red are purple, and the tip of the nose, instead of being white, is one patch of ecchymosed venous blood. The urine is often defective in quantity, but is sometimes natural and sometimes in excess. The skin is dry and the patient thirsty; his appetite greatly impaired, and his spirits greatly depressed.

The progress of the disease is seldom accompanied by any severe constitutional symptoms; but at length the legs and scrotum become greatly distended, and often inflame, so that the patient sometimes ultimately falls from gangrene of these parts. Again, bronchitis may take place; or, the urine becoming nearly suppressed, effusion may occur in the chest, or in the head, and the patient die comatose, or of hydrothorax.

The favourable circumstances are, the secretion of urine being re-established and becoming natural, the subsidence of the anasarca and of the ascites, and then a gradual return to health.

The presence of water in the abdomen is determined by percussion of that cavity; and the best mode is to place one hand on the abdomen, and to give a sharp but gentle tap on the opposite side with the fingers of the other, when, if water be present, a fluctuation will be felt; when, however, the quantity of fluid is small the fluctuation is best felt by percussing the side of the abdomen, or from before backwards. The existence of fluid in the cellular tissue of the trunk or extremities is determined by the finger leaving a mark or "pit;" the water, being inelastic, is displaced, and thereby graviting back the part does not recover its original form and fulness for some seconds.

The ascites may form suddenly and the patient be distended in a few hours, or it may take weeks or months for the fluid to accumulate. The duration of the disease is very various. If the effusion be general, the patient's life may terminate in a few days; but more commonly the affection is chronic, and the patient survives many weeks or months. Such are the more general laws of ascites; but it is now necessary to pass to those particular forms which constitute its varieties.

Ascites sometimes results from the large effusion of serum which is poured out occasionally in acute forms of *Peritonitis*. In this case the abdomen is extremely painful, the pain much increased on pressure, and the pulse quick. The patient very generally recovers from this affection; but if he falls death usually occurs within a very few weeks from the first attack. Ascites sometimes results from chronic peritonitis; and now, although the patient sometimes suffers much pain, more commonly this symptom is wanting, or only occurs in occasional paroxysms; so that he appears ultimately to fall from the conjoint effects of the anasarca and of the ascites. The urine is scanty, but for the most part free from albumen in both these forms of disease.

A *diseased heart*, or diseased state of the aorta, is often the primary cause of ascites, and in this case also the urine seldom contains any albumen. The heart's *bruit*, its impulsion, together with the character of the pulse, will in general give the particular lesion under which the party labours. This dropsy may first show itself either by effusion into the abdomen, or else into the cellular tissue of the lower extremities, causing anasarca. When effusion has taken place, it is remarkable that the action of the heart becomes more regular, its impulse more natural, the pulse slower and steadier, while perhaps the *bruit* disappears altogether. This apparent amendment, however, is fallacious, for the dropsical symptoms increase, effusion takes place first into one cavity and then into another, so that the patient seldom long survives this fatal symptom. The urine in this form of dropsy is generally deep in colour, small in quantity, and of a healthy density.

When ascites arises from a *diseased liver*, that viscus is generally enlarged, especially the left lobe; but it is, in some instances, smaller than usual. The ascites in this case has no new feature, except that the patient may or may not be jaundiced. In the former case all the fluids effused are of a yellowish or greenish yellow colour. The urine also is loaded with bile, which is generally turned green by the addition of nitric acid; while in a smaller number of cases the bile appears to be in a peculiar state of combination with the urine, so that the acid has now no effect on it; the urine likewise is always small in quantity, much loaded with the usual salts, and of a high density. The bowels are difficult to act upon, and the patient is liable to severe abdominal pains similating chronic peritonitis. The pulse continues throughout the disease for the most part natural, and the patient usually falls into a more or less typhoid state, from which there is no recovery.

In ascites from disease of the *spleen* the urine is also in general healthy, though scanty in quantity. This viscus is uniformly enlarged, and can readily be felt occupying the left hypochondriac region, and thus the cause, though not its exact nature, can be determined; for we have no diagnostic symptoms denoting whether the spleen be simply hypertrophied or in a cancerous or tuberculated state. The early symptoms are similar to what occur in dropsy of the liver; but the termination of the disease, if the patient falls, is singular, or by hæmorrhage from the stomach and bowels, often so profuse as to amount to many pints in a few hours, greatly exhausting the patient, and hastening the fatal catastrophe.

In dropsy from disease of the *kidney* the urine may or may not contain *albumen*; but in the great majority of cases it does so. When albumen is absent, as the chronic forms of diseased kidney are all devoid of pain, we are unable to determine either the seat or the nature of the disease with which it is affected, and the ascites is consequently in general attributed to an affection of the peritoneum, of the liver, or other viscus. When, however, albumen is present, it may arise from mere functional disease of the kidney; from its being beset with hydatid cysts; or from its being indurated, or the seat of other structural disease; but by far the most common cause, however, of albuminous urine is that peculiar degenerescence called Bright's or the granular kidney. This term embraces many different

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stages or chronic forms of disease; but as these are all devoid of pain or other local symptoms, the particular form of disease is a mere matter of calculation deduced from pathological investigations. The dropsies which follow this latter morbid state of the kidney are frequent, are accompanied by albuminous urine, and follow many singular laws.

In dropsy arising from granular kidney, the lower extremities generally first become anasarcous; and this is so constantly the case that the disease is usually termed the "leg dropsy;" and, after this, effusion usually takes place into the cavity of the abdomen, and subsequently perhaps into that of the chest and head. The anasarca, however, is not confined to the lower extremities, but the whole cellular tissue of the body is often infiltrated with serous effusion. Thus, the trunk, the chest, the arms and hands, as also the face and neck, are often wonderfully swollen and distended in this extraordinary and fatal disease. The effusion having taken place, Dr. Christison divides the disease into three stages, principally deduced from the state of the urine. It must be admitted, however, that these stages are not always well marked, and that much difference of opinion exists as to the phenomena of the latter stage.

In the first stage, the quantity of urine passed is sometimes natural; in a few instances it is increased; but far more generally it is diminished. Most usually in colour it differs little from that of health; but it is turbid from being mixed perhaps with a small quantity of mucus. A sediment, too, sometimes forms in this stage, which is either lithic acid, or the lithate of ammonia, or bubbles form as with soap and water. In a smaller number of cases the urine is of a blood-red tint, occasionally mingled with clots, and sometimes with pure blood, which afterwards coagulates.

By far the most remarkable property of the urine, however, in this as in every other stage, is its coagulability under the action of heat or acids, showing the presence of albumen. The quantity of albumen varies greatly, sometimes the addition of the acid merely rendering the urine opaline, while at other times the albumen is precipitated in heavy white flakes, which occupy from one-third to three-fourths of the whole space of the urine tested. Still, though the apparent volume of the albumen is great, yet its weight is trifling, for 10 parts by weight to 1000 parts of urine will render it almost a thin uniform pulp when heated. The greatest quantity Dr. Christison has met with is 27 parts in 1000; and in this case the urine was converted into a solid gelatinous mass, from which no fluid issued when the tube was turned upside down.

Besides containing albumen, the urine also deviates from the healthy standard in containing a less quantity of its usual solid ingredients; the daily discharge of solid matter being from one-sixth to one-fourth less than the healthy average. The loss of weight is chiefly in the urea, but the salts are likewise diminished. The urea is not only deficient in quantity, but is supposed to be imperfectly formed, the urine having a great tendency to undergo decomposition. Another remarkable property of this urine is, that although loaded with albumen, its specific gravity is reduced; or supposing the healthy average to vary from 1020 to 1030, it now varies from 1016 to 1025. The pathognomic characters of the urine in the incipient stage of granular disorganization of the kidney are, then, a moderate reduction of density, an albuminous impregnation, and a material diminution of the solid ingredients.

As the disease advances, the second stage forms, and the quantity of urine is now often little below the standard of health, and in most instances even much exceeds it, the patient passing sometimes from 100 to 130 ounces daily. Its colour is generally pale, and its specific gravity much reduced, sinking to 1016, 1012, 1008, and even as low as 1004. Albumen is still thrown down by the usual tests, and if the quantity of urine is small, that substance is greatly abundant and flaky; when, however, the quantity is increased, the proportion of albumen seems diminished, either the now greatly impoverished state of the blood affording a less amount of it, or else that it is diluted by the greater amount of watery urine. The other solid contents are also reduced, or from 67·7 parts in 1000 to about 24 parts in 1000.

In the third stage, according to the observation of most writers, the quantity of urine decreases, and the proportionate quantity of albumen is increased till at last the urine is in some cases almost altogether suppressed, or else nearly pure blood is passed; and there are even cases in which the urine contained in the bladder has been found coagulated after death. Dr. Christison, however, states as the result of his practice, that the albumen diminishes in this stage.

Besides the alterations in the urine, changes not less remarkable take place in the condition of the blood. The density of this fluid in health is between 1029 and 1031; but in granular degenerescence of the kidney it is often as low as 1020, while the solid contents are reduced from 100 or 102 in 1000 to 68, 64, and even to 61 parts in 1000. This reduction equally extends to the albumen as well as to the saline ingredients, so that the serum is often greatly deficient in that substance, and coagulates but loosely when heated.

Another not less remarkable departure from the healthy constitution of the blood is the presence of a large quantity of urea in the circulating fluid. This fact was first hinted at by Dr. Bostock, and has been subsequently established by Dr. Christison, who affirms that when the urea is reduced by disease to one-third its natural amount in the urine, it is always to be detected in the blood. Again, while the other constituents of the blood are diminished, the fibrine is usually increased in this remarkable disease, or instead of 25 to 52 parts in 10,000, the proportion in health, it now varies from 32 to 80 parts in 10,000. This augmentation is supposed to depend on the degree of constitutional re-action caused by the local inflammation under which the patient so often labours. Dr. Christison, from whom these details are borrowed, states that the hæmatosine or colouring matter of the blood is little affected, and also that in advanced stages of the disease the density and solid contents of the serum, which have been shown to be invariably reduced at the beginning of this affection, gradually return to the healthy standard, and even exceed it. This, however, can be by no means constantly the case.

The extraordinary manner in which the blood becomes impoverished and robbed each successive day of a portion of its most nutritive ingredients, must prepare us to expect many diseases both of function and of structure in the course of this affection, and there are few organs or tissues that do not suffer. The most frequent lesions are perhaps those of the alimentary canal. Impaired function of the stomach is frequent in every disease of the kidneys; but in this affection it is often so excessive as to constitute a disease more distressing even than the original complaint. In some cases the stomach suffers from simple dyspepsia, in others from sickness with oc-

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casional vomiting, while in others everything is returned. This chronic vomiting is most frequent in the second stage of the disease.

Another very common symptom in albuminous urine dropsy is diarrhœa. This affection generally arises from irritability of the coats of the intestines, but it occasionally terminates in ulceration of the bowels. It is frequently but not always attended with pain. The evacuations are loose, but present nothing remarkable, except being occasionally intermixed with portions of shred-like matters. This diarrhœa is sometimes mild, but more often severe, and greatly exhausts the patient without reducing the dropsy. This affection is common in every stage of the disease.

Besides functional or structural disease of the mucous membrane of the alimentary canal, the peritoneum is liable to be inflamed, and the patient to be thus prematurely cut off. Dr. Bright found traces of inflammation of this membrane in 45 cases in 100, and in 12 or 13 it was extremely well marked. The symptoms in this case are of course great pain of the abdomen, with a rapid and small pulse.

The lesions of the organs contained in the chest are as frequent as those of the abdomen. Bronchitis with purulent secretion is extremely frequent, and is always a complication indicating much danger. In some instances it is associated with emphysema of the lung, producing urgent dyspnœa. The substance of the lung, however, is seldom inflamed, Dr. Bright having found only 5 cases in 100 in which there were any traces of recent or of old pneumonia; but œdema of the lung is frequent, it having occurred 31 times out of the 100 cases. Apoplexy of the lung has also been met with.

The pleura is, however, of all the tissues of the respiratory organs, that which is the most commonly affected, it being found more or less diseased in 3 cases out of 4; or in 40 cases there were old adhesions, in 16 cases evident signs of recent inflammation, while in 41 cases there was water effused into the chest.

The heart has been found diseased in 69 cases out of 100, and the lesions have consisted chiefly of hypertrophy, with or without valvular disease. In 52 cases of hypertrophy, chiefly of the left ventricle, no valvular disease could be detected, but in 34 of these the aorta was more or less diseased. When the valves have been found diseased, they have been for the most part those of the left side of the heart, or the aortic and mitral valves. When disease of the heart is conjoined with granular kidney, the patient often suffers from severe and fatal hæmorrhage from the bowels.

Solon says, of all the influences which granular kidney exercises over the œconomy, the gravest is that which it exerts over the brain. The first symptom of the affection of this organ is long-continued and severe headache, then obstinate somnolescence, and lastly coma; and 8 cases out of 10 are supposed to terminate fatally, either by convulsions, coma, or by serous epoplexy. But although these symptoms are formidable, the lesions are limited to the membranes, and these are sometimes absent, for in 48 cases only out of 100 Dr. Bright found the arachnoid diseased; or in 13 cases it was opaque, in 29 serum was effused into its cavity, and in 6 there was water in the ventricles. The substance of the brain has been for the most part found healthy.

It is singular that the liver, spleen, and pancreas have a great immunity from disease in this form of dropsy, a fact the more remarkable as the patients are often habitually intemperate. The instances of confirmed disease of structure of these parts were so few, that they did not amount to more than 18 in 100 cases, while in 32 the deviation from the natural structure was exceedingly slight, little more than a mottled state caused by an irregular distribution of blood throughout the texture, a condition frequently observed when the circulation through the chest is obstructed. Such are the peculiar symptoms which the different genera of ascites present.

*Diagnosis.*—Ascites is readily distinguished in the male from every other intumescence of the abdomen by the fluctuation on percussion. In the female it can only be confounded with ovarian dropsy.

*Prognosis.—The prognosis* in enasarca in young persons not labouring under any organic disease is always favourable. If, however, it be consecutive to organic disease, a fatal termination is ultimately to be feared.

Ascites arising from indeterminate causes is often recovered from, but no case is free from danger, the peritoneum often taking on the character of a cyst, and resisting the action of all medicines.

Ascites depending on moderate inflammation of the peritoneum is often recovered from, and especially if the inflammation depends on the action of the paludal poison.

Ascites with albuminous urine, arising from mere functional disorder of the kidney, is generally recovered from; but if the structure of the kidney be impaired, the disease is always grave and generally fatal. In a few cases, however, the disease subsides, and the patient continues well for two, three, or four years, when he generally relapses and dies.

Ascites from disordered function of the heart is often recovered from; but if it depends on diseased structure either of the heart or large vessels, some temporary amendment may take place, but the patient quickly relapses and finally sinks.

Ascites depending on diseased structure of the liver or of the spleen is rarely recovered from unless the primary disease be cured.

*Treatment.*—The ancients witnessed so few recoveries from dropsy, that they looked on the restoration of the patient as an accident, or as a special blessing from heaven, rather than the result of physical causes. The treatment of ascites in the present day, it must be admitted, is often unsuccessful; still it may be affirmed that one-half the patients are cured, which is abundantly sufficient to overthrow the opinions of the earlier schools. The treatment of any given case is often, however, of great difficulty; for the remedy which will cure one patient has frequently failed with another, and apparently under exactly the same circumstances. All that can be done, therefore, is to lay down some general rules, leaving their particular application to the discretion of the practitioner.

When ascites occurs without any obvious cause, and without albumen in the urine, the best medicine is unquestionably the bitertrate of potash, first introduced by Vicenti Manghini. This valuable remedy may be given either in divided doses, as ʒ j three times a day, or every six hours, or else in one large dose, as half an ounce, strengthened, if the patient's bowels be confined, with ten to fifteen grains of jalap. When the smaller doses are used, it is often exceedingly useful to add ten grains of the citrate or tartrate of iron to each dose. If these remedies should fail, a grain of elaterium every night or every other night may be tried.

There is one form of ascites, without any obvious cause, in which the accompanying anasarca is caused by effusion of serum into the intermuscular tissue, and be-

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neath the fascia of the legs, rendering them extremely hard and tense. Under these circumstances squills appear to be the best remedy, and by giving five to eight grains of the pulvis scillæ three times a day, the dropsy is always relieved and the patient sometimes recovered. If the stomach be irritable, half a grain of opium should be added to each dose, so that it may be retained.

Should the ascites arise from simple inflammation of the peritoneum, this form of dropsy in general yields to leeches and fomentations to the abdomen, together with the sulphate of magnesia ʒ j. c. tinct. hyoscyami ♏ xv. every six hours. If, however, the case be severe, some mercury may be necessary, as the pil. hydrargyri, or moderate doses of the chloride of mercury.

When the inflammation depends on a morbid poison, the treatment varies according to the nature of that poison. Thus, if it be the result of the paludal poison, preparations of mercury are essential, and the ascites is cured as soon as the mouth is affected. On the contrary, should the ascites or anasarca arise from the poison of scarlet fever, it is in general necessary to bleed the patient. The quantity of blood taken should be proportioned to the age of the patient: a child of six years of age may lose from four to six ounces, an adult ten to sixteen ounces. After this, almost any active purgative will effect the cure,—as the bitartrate of potash, the sulphate of soda or magnesia, or repeated doses of rhubarb or jalap. In many cases, however, it is necessary to combine the purgative with some mild tonic, as the tartrate of iron, or with salicine.

When the ascites arises from disease of the heart, the kidney being sound, and the urine free from albumen, the treatment must have reference to the nature of that disease. If the valves of the heart are ossified or otherwise diseased, the patient, though he cannot recover, may be greatly relieved, and mist. camphor. ℥ iſs. c. sp. ætheris nitrici ʒ j. c. tinct. hyoscyami ♏ xv. c. tinct. digitalis, ♏ xv. c. magnesiæ sulphatis, ʒ j. ter die vel 6$^{\text{tis}}$ horis, this mixture often greatly reducing the dropsy. When the stomach will bear it, the tinct. scillæ ♏ x. to ♏ xx. with a drachm of the acetate of potash, has occasionally succeeded. Small doses of elaterium, as $\frac{1}{4}$ to $\frac{1}{2}$ of a grain ter die, is a medicine that is also sometimes useful. Blisters to the cardiac region give relief; but it should be remembered that heart cases bear bleeding badly, and that operation should be avoided except in one case, or when blood is expectorated. If blood, however, appears in the sputa, ten to sixteen ounces may be taken not only without injury but with great benefit. In those cases in which the valves still continue healthy, but in which the heart is enlarged and hypertrophied, and has acquired a rolling irregular action, the dried seeds of iberis amara are the best remedy. The dose is from iij. to v. grains three times a day.

The ascites may be caused by disease of the liver; and should that organ be merely inflamed or hypertrophied, without other alterations of structure, the dropsy is often cured. The treatment is by bleeding, and the neutral salts, as the sulphates of magnesia or of soda, or, should they fail, by moderate doses of calomel. When, however, its structure is otherwise altered, the patient is seldom cured; but the disease may still be alleviated and life prolonged by mercury pushed often so as to affect the mouth. In this form of ascites the patient suffers greatly from abdominal pains, which can only be relieved by hot bottles or fomentations. In these cases, also, the bowels are often greatly constipated, and require the most powerful drastic purgatives, as the black draught, castor or croton oil, or elaterium. In this form of dropsy, however, the peritoneum partakes more of a cyst than in most of the others; the water is therefore seldom reduced, and the patient generally requires the last imperfect resource of the art, or tapping.

Ascites depending on enlarged spleen is also difficult of cure. If the spleen be simply hypertrophied, the bromide of potash, in doses of five to eight grains three times a day, is perhaps the most efficient remedy, and after that the iodide of potassium. The patient, however, often falls from hæmorrhage after all the more prominent symptoms have been relieved.

The dropsy which often occurs in young chlorotic women, in which the urine *contains albumen*, the kidney, being healthy in structure though disordered in function, is generally cured; and the remedies which are most efficient are salicine gr. x. ter die, or else the bitartrate of potash, ʒ j. ter die. The former is a mild tonic, has considerable power in restoring menstruation, and likewise acts on the bladder. The cream of tartar also is an excellent remedy, both as a diuretic and as a purgative in these cases.

Ascites, however, with *albuminous urine*, and depending on the *granular* kidney, as it is the most common form of dropsy so it is the most intractable. The difficulty of the treatment is also enhanced by the fact that the remedy which succeeds with one patient will often entirely fail in another exactly similar case, while a large class of these patients are not beneficially influenced by any treatment yet proposed. The most general rules we can lay down are as follows.

Many practitioners, from the number of secondary inflammations which follow in the train of albuminous dropsy, have considered this disease to be inflammatory, have termed it '*inflammatory dropsy*,' and consequently have recommended bleeding as the cardinal point on which the treatment turns. It should be remembered, however, that inflammation is as assuredly produced by defect as well as by an excess of nervous excitement. In albuminous urine dropsy, therefore, the blood is impoverished by the loss of a considerable portion of its albumen, and consequently it seems to follow that the inflammation is of an asthenic character, and, so far from being controlled by bleeding, is likely to be rendered more intense and fatal by that operation. The profession, however, is divided on the subject: Dr. Blackall, Dr. Christison, and Dr. Elliotson recommend bleeding: Dr. Bright uses the lancet with extreme caution, while many able practitioners forego its use altogether. In general bleeding does not diminish the quantity of serum in the urine, while it enfeebles the patient, even when young and of considerable powers of constitution. It may not do all the mischief that might have been expected from it, but it certainly does not do the good that has been attributed to it.

With respect to remedies, by far the greater number that recover are cured by the bitartrate of potash, or by similar remedies, as the binoxalate of potash, or the oxalic acid. The irritable state of the bowels in this disease hardly allows large doses of these medicines to be employed; and a drachm of the bitartrate of potash three times a day, or ten grains of the binoxalate of potash, or of oxalic acid, also exhibited the same number of times in the day, are as large doses as the patients will generally bear, and even in many of these cases a grain of opium is necessary at night to enable them to continue their use. The action of these diuretics is often

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Elementary Principles of Medicine.

much assisted by some vegetable or mineral tonic, as the ferrum tartarizatum, of which ten grains may be given three times a day, or else the salicine, of which ten grains also may be given at similar intervals.

When the supeacid salts fail, the patient is not to be abandoned, for by some inexplicable affinity or susceptibility, other remedies will occasionally take up the disease. Thus one patient, in whom the bitartrate of potash failed, was recovered by salicine, gr. x. ter die. Another, in whom both the bitartrate and salicine had failed, was cured by the dried seeds of the iberis amara, gr. iij. to v. ter die;—others again are relieved by squills; and others, perhaps, by the bryony root. When the bones have been diseased, the iodide of potassium has cured the disease; while in affections of the heart, digitalis has occasionally emptied out the patient. These are isolated instances of success, still they ought to induce us not to abandon the patient unless after trying an extensive series of substances, and happily by perseverance other medicines may be discovered still more beneficial in this fatal disorder.

As yet nothing has been said with respect to mercury, a well-known and powerful agent in the cure of inflammation, and which has been extensively used in albuminous urine dropsy. In some very few instances it may have cured the disease, and in a few more relieved the patient; but in general, if the water has disappeared under its use, this subsidence has been the immediate forerunner of death. Again, the majority of patients are so susceptible of the action of this metal, that they have fallen into most profuse ptyalism, large portions of the jaw have exfoliated, and they have at length sunk, after much deplorable suffering. Among the negantia in this disease then are bleeding and mercury, and to them may be added elaterium and cantharides.

Such is the general treatment of this disease, but there are many particular symptoms in its course which require to be combated, and which we have often in our power to alleviate. *Chronic vomiting* is one of the most distressing concomitants of this affection, and is to be met by the effervescing draught, combined with ♏ j. or ♏ ij. of hydrocyanic acid, or with ♏ iij. to ♏ v. of tinct. opii. One or two drops of creosote out of an aromatic water may also be tried. These are perhaps our most efficient remedies in this complaint; "but the physician," says Dr. Christison, "ought not to be surprised if he finds all these remedies ineffectual." It is this tendency to chronic vomiting which renders the propriety of administering squills so doubtful in this disease.

*Diarrhœa* is common in this disorder, so that it is almost always necessary to combine the purgative salt with some opiate; and sometimes the bowels are so singularly irritable as to oblige us to abandon all opening medicine, and to prescribe astringents, as kino, catechu, or hæmatoxylum, or else the mistura cretæ composita c. opio, and even pure opium, to the amount of two, three, or four grains a-day: and in addition to this the patient should be supported by small quantities of wine or brandy. Dr. Christison speaks highly of the acetate of lead in these cases; but under any treatment this symptom is dangerous and distressing.

Inflammation of the peritoneum, when combined with albuminous urine dropsy, presents likewise great difficulties in its treatment; for if the patient be bled he is often not relieved, and if that operation be neglected, he most commonly dies. The usual treatment of this symptom is by leeches, fomentations, mercury, and opium.

Inflammation of the pleura presents the same difficulties as peritonitis, every present mode of treatment being most unsatisfactory. Œdema of the lung, or effusion into the cavity of the chest, are also generally fatal occurrences, and without remedy. The bronchitis is perhaps best treated by blisters, anodynes, and small doses of squills. The affections of the heart in this, as in all other forms of dropsy, are exceedingly intractable; but iberis, digitalis, with or without æther, for the patient generally requires support, and also occasional small bleedings, if hæmoptysis should occur, are those remedies which usually give most relief.

In the chronic headache, with which the patient is often troubled, small doses of arsenic, as one-twentieth of a grain three times a day, have several times removed it. When effusion takes place into the cavities of the brain and of the arachnoid, the patient's state, whatever be the modes of treatment employed, is generally hopeless.

The treatment of the various forms of ascites that have been detailed, though often successful, yet is frequently inefficacious, the peritoneum partaking more and more of the properties of a cyst, so that the abdomen becomes greatly distended, anasarca of the legs extends upwards to the thighs and trunk, while the scrotum is distended almost to bursting. Something more then is often necessary to be done to relieve the patient; and we have it in our power to draw off the water by tapping the abdomen, or by scarifying the legs, or by puncturing the scrotum. In making this choice, however, we are surrounded with difficulties; for the operation of paracentesis is not lightly to be hazarded, since it rarely cures the disease in its simplest forms; and when it is connected with disease of the heart, the liver, or the kidney, the relief is but temporary, for in a few hours the patient rapidly fills again, and becomes more distended than before. The operation also diminishes the chances of ultimate recovery; for unless the patient recovers, the peritoneum is rendered greatly more insensible to the action of remedies, while peritonitis may follow, and at once destroy the patient. Still, notwithstanding these adverse chances, the patient's state is often so deplorable, and he so earnestly entreats for the operation, that there are cases in which it is justified.

Scarification of the legs, or puncture of the scrotum, is apparently a much more simple and harmless operation than paracentesis, no vital organ or tissue being immediately injured, while the drain of water is often considerable. These advantages, however, are completely counterbalanced by the very constant occurrence of inflammation, at least in London, after these operations. If the scrotum be punctured, the inflammation usually begins in the skin, extends to the cellular tissue, and at last involves the testicles, and the pain in these cases is not only severe, but amounts to agony. Nor is the patient relieved, except by the supervention of gangrene; and even if gangrene takes place, the skin often survives the death of the cellular tissue, so that the agony is little mitigated, and thus he often dies in horrible torments. Scarification of the leg is also very generally followed by inflammation, also terminating in gangrene; but although the actual suffering in this case is less severe than in the former, still it is often agonising, irremediable, and accelerates the death of the patient. No law is perhaps better determined in medicine than that of not scarifying, unless in some extreme cases, either the legs or scrotum of a dropsical patient. It has been thought that a minute puncture, as with a needle, would obviate

this difficulty; still, if a puncture be large enough to allow a drop of fluid to escape, the parts over which it flows become irritated by its acridity, and inflammation follows, perhaps as soon and as severe as when a larger opening is made. It has been attempted to explain this phenomenon by affirming that the effused fluid contains urea, and has therefore the properties of urine. This may be probably the case, but it lies without action in the sound cellular tissue, which urine would not do; while urine which flows over the healthy skin leaves little trace behind.

HYDROPS OVARII—OVARIAN DROPSY—

Is an effusion of a watery fluid into one or more cysts formed in the ovary, and is a disease known from the earliest antiquity.

*Remote Cause.*—The remote cause of this form of dropsy is hardly known, so that it probably arises from slight causes acting upon a particular idiosyncrasy. Its more obvious causes are mechanical injuries, as well as all those causes which act upon the uterus, producing menorrhagia or amenorrhœa.

*Predisposing Causes.*—It is doubtful whether any case is known before puberty; but Franck mentions having seen a young person of thirteen years of age labouring under this disease, and Siard one of fourteen. It sometimes occurs between twenty and twenty-five, but is most common towards the period of the cessation of the menses, and from that period till sixty. It occurs in the unmarried as well as in the married female.

*Pathology.*—The seat of this disorder is supposed to be the Graafian vesicles, or else the cellular tissue which connects them, or perhaps both. These vesicles, or cells, probably by a process of achromatous inflammation, form cysts, which secrete a fluid like water in much greater abundance than it is absorbed, so that it acts as a distending force, which slowly augments, till at last the cyst or cysts acquire an extraordinary size, containing many gallons. The walls of the cyst are at first transparent; but as the disease advances they become thickened, opaque, and of considerable tenacity, so much so, that in some instances they are cartilaginous, and in others osseous. The size of these cysts is often so great that they rise above the pelvis, thrust the liver and spleen into the chest, and at length fill the whole abdomen.

The number of these cysts is very various, but most commonly there are from three to six, and even many more. They are very uniformly of different magnitudes, and in general the largest occupies the anterior portion of the ovary. Examined externally, the tumor is irregular and knobbled from the projection of the smaller cysts. When the disease is advanced, nothing is more variable than the nature and quantity of fluid these cysts contain. Often in the same ovary there are as many different fluids as there are cysts; one being filled with serum; another with a fluid like thin honey and water; a third with pus; and a fourth, perhaps, with a fluid like chocolate grounds, or blood, more or less modified. It is the great density of many of these fluids which causes the tumor often to feel hard and to be void of fluctuation, and consequently sometimes to be mistaken for fungus hæmatodes, or other solid substance.

The quantity of fluid which these cysts contain is as various as its quality. At first the cyst is small, and its contents hardly exceed a drachm; but in advanced stages of the disease the cyst has been known to hold 120 and even 140 pints, much exceeding, perhaps, the entire weight of the woman's whole body.

On examining the body after death, we usually find some fluid effused into the cavity of the abdomen; the cyst also often adherent to the walls of the abdomen, and the intestines glued together in consequence of the inflammation caused by the great pressure. If the patient has fallen after tapping, the inner walls of the cyst are often actively and extensively inflamed, and perhaps filled with pus. It is seldom that both ovaries are found diseased, and in a very few instances the cyst has been found pediculated, or else formed in the Fallopian tube.

*Symptoms.*—The early stage of ovarian dropsy is often little marked, and the disease silently forms without any symptom, or only some slight uneasiness in the ovarian region, and in a very few instances by some occasional attacks of severe abdominal pain, probably from the setting up of adhesive inflammation.

In this incipient stage the tumor is often long stationary, but at length it rises above the pubes, and then it may rapidly or slowly enlarge, till it fills the whole abdomen. The general health is also rarely impaired till the tumor attains an inconvenient size, and presses upon and displaces the surrounding viscera; under these circumstances the urine, which was passed naturally as to quantity and as to time, is either long retained or voided frequently. Pain also is felt in the loins and down the thighs. The bowels are costive, and the catamenia either irregular or suppressed, and, from the general debility, the patient towards the close of the disease becomes hysterical. Besides these local symptoms, the legs become anasarcous, and ascites is at length added to the original affection. Under this general impairment of the functions of the different viscera, the health of the patient sinks, she is unable to lie down from her unwieldly size, the powers of life are exhausted, and death puts a period to most protracted suffering.

The whole duration of this affection is very various, or from a few months to two, three, or four years.

*Diagnosis.*—This disease is to be distinguished from hydrops uteri only by an examination, and from encysted dropsy of the liver, or other encysted dropsy of the abdomen, only by its situation. The greatest difficulty, however, is to distinguish it from fungus hæmatodes of the mesentery; for when the fluid in the ovary is of much density there is no fluctuation, and the sensation it gives is that of a solid body. The fungoid tumor, however, generally forms higher up and more in the centre of the abdomen, and is thus distinguished by its locality.

*Prognosis.*—A very few cases have been supposed to have recovered from ovarian dropsy; such instances, however, are only exceptions to the general fatality of the disease, and consequently the prognosis is uniformly most unfavourable.

*Treatment.*—The profession generally are perhaps more agreed upon the entire nullity of all remedies in the cure of ovarian dropsy than perhaps on any other fact in practical medicine, and are almost universally of opinion, with Dr. John Hunter, that the patient will have the greatest chance of living longest who does the least to get rid of it. The medical treatment is, therefore, almost limited to obviating symptoms, regulating the bowels, and increasing the flow of urine so as to keep down the anasarca and ascites which are so commonly present.

As the medical treatment of ovarian dropsy is at present only palliative, paracentesis in some instances becomes imperative, owing to the urgency of the symp-

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toma. This operation, however, should be delayed as long as possible, from the multilocular nature of the cyst; for supposing one cyst to be emptied, there are in general several others quite out of the reach of the trocar. It should also be delayed from the danger of inducing inflammation in the cyst itself, and thus distroying the patient with tenfold suffering. Under the most favourable circumstances, also, the fluid soon collects again, and the patient is thus obliged to submit to a frequent repetition of the operation. One patient mentioned by Morand underwent 30 operations in 25 years, and had drawn off 6600 lb., or perhaps 60 times her own weight. Another instance, a Mrs. Mumfurd was tapped 55 times in four years.

It has been proposed, after tapping, to effect a radical cure by laying open the tumor, or by keeping a canula inserted in it; but as very few cases are mentioned as having recovered by this practice, the multilocular nature of these cysts, and the danger of inflammation, must ever prevent the humane physician from recommending it.

Besides tapping the cyst, the extirpation of the entire ovary has been proposed, and, as it appears, has been successfully performed by L'Aumonier of Rouen, and by Drs. Smith and Macdowal of the United States. The operation proposed has been an incision through the walls of the abdomen, and then raising the sac to eradicate it by ligature or other means. This practice has been repeated in this and other countries by Blundell, Lizars, Dieffenbach, and others, but, except in one instance, it has entirely failed. In three cases the patients died of the operation, and in a fourth the surgeon did not proceed with the operation, finding the tumor adherent on all sides. Mr. Walne, however, has very recently performed this bold operation, and with success, in two cases. Another mode of curing the patient is by acupuncturation, which M. Bonfils recommends, and states that it has in some instances been successful. This operation is entitled to a more extended trial than has yet been given it, for the generally multilocular nature of these tumors renders it hardly possible that tapping should be in any instance ultimately successful.

When these methods have either been rejected or failed, a last mode of relieving the patient is by puncturing the legs, which are often greatly swollen, rendering it impossible to flex them. The operation in this case is liable to even greater objection than in ascites; for, besides the punctures very commonly inflaming, the relief by this method must be very trifling, while the chance of a cure is entirely hopeless.

The treatment of ovarian dropsy presenting so few chances of success, it is grateful to be able to add, that in a very few cases a spontaneous cure has taken place. Dr. Baillie mentions an instance of its spontaneous disappearance after it had existed three years, the patient remaining subsequently in good health. Instances have occurred to Dr. Elliotson, to Dr. Montgomery, to Dr. Copland, and others, of the tumor having formed adhesions to the intestines or to the vagina, and rupturing, and thus discharging its contents into those cavities; and Dr. Seymour mentions a case in which the tumor burst into both canals, and recovery took place. The ovary has sometimes also formed adhesions to the abdominal parietes, and has burst externally, and the patient recovered. Dr. Blundell has, in his published lectures, given a case of rupture into the cavity of the abdomen, and of the patient being restored by absorption of the effused fluid.

*Dropsy of the Fallopian Tube.*—A cyst sometimes forms in the fold of the ligament, either near the uterus, or near the ovarium, or near the fimbriated extremity of the tube. This disease has been described by Drs. Baillie and Monro. The cyst thus formed is quite as large as that of the ovarium, Cypriani having found one that contained 150 pints, and Hardie another, only something less, or 140 pints of fluid. No distinction can be made either as to symptoms, course, causes, or treatment, between this disease and ovarian dropsy.

*Hydrometra—Dropsy of the Uterus.*—This disease is of very rare occurrence, and will be better illustrated by a case than by any general description. The following instance is related by Dr. A. T. Thompson, in the *Medico-Chir. Transact.*, vol. xxiii. p. 170.

Mary Rae, at 65, the mother of several children, was admitted into the infirmary in Dec. 1823. She appeared as large as if six months gone with child. It was suspected she was labouring under a diseased ovarium, and an indistinct fluctuation was perceptible in the tumor. There was, however, a greater derangement of the system than usually attends dropsy of the ovarium, as loss of appetite, considerable nausea, furred tongue, quick and feeble pulse, the bowels irregular, and the urine scanty and high-coloured. She died in March, 1824, after amputation of the leg, which operation was performed in consequence of a dry gangrene which had attacked the limb. On dissection the tumor was ascertained to be the uterus greatly enlarged and filled with fluid. It was partially sphacelated on its peritoneal covering at the upper portion of the fundus. On making an incision into it, eight measured quarts of a dark-coloured fluid, which coagulated slightly when heated in a spoon over the flame of a candle, issued from it. The internal surface of the organ was not more irregular nor more spongy than in its natural state, but none of the orifices could be found, for even the os uteri was, interiorly, as completely obliterated as if it had never existed; and although its situation could be traced in the vagina, yet even there it was very faintly marked. In this case the bladder was so stretched as to extend to within an inch of the umbilicus, and must have been perforated by the trocar had any attempt been made to perform the operation of paracentesis.

## CLASS II.

### Of Diseases of Structure.

However fertile a source of illness and of painful suffering the large class of the Neuroses may be, still, of the 340,000 to 350,000 deaths which annually take place in England and Wales, there can be no doubt that upwards of 300,000 are caused, either primarily or secondarily, by diseases of structure, including those produced by the class of morbid poisons. The diseases of structure are, therefore, of vast importance, so much so that many pathologists have considered them as constituting the whole body of medicine. It is proposed now to divide them into four great divisions; the 1st embracing Inflammations having no specific character, also Malaxoma, Scleroma, Atrophia, and Hypertrophia; the 2nd, Tuberculoma; the 3rd, Carcinoma; and the 4th, Melanoma.

It is also proposed to give the general laws of inflammation, of the formation of cysts, of hypertrophy and of atrophy under one head, in order not to break this short treatise into too many parts.



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ORDER I.—OF INFLAMMATION.

Nature repairs the injuries of organized substances in two different ways, or by reproduction and by inflammation. In the vegetable kingdom and in the lower classes of animals the power of reproduction is considerable, a part sometimes reproducing the whole vegetable, or the whole animal; but in man this power is extremely limited, or to the hair, the nails, and the cuticle; for an eye destroyed, or a leg amputated, is never reproduced, the wounds thus occasioned being healed by inflammation. Every part, therefore, or nearly so, being liable to injury, is provided with a *power* of inflammation, and on this property the surgeon relies for reuniting the tendon he divides, for obliterating the artery he ties, and for healing the wound he makes. This power of inflammation, however, is destructive as well as preservative, and is liable to be excited by many other causes than mechanical injuries, or by the numerous class of morbid poisons, by intemperance, the play of the passions, atmospheric vicissitudes, and other circumstances. Inflammation, consequently, has many causes, is of very frequent occurrence, and as it affects every organ and every tissue of the body, is of such extent as to form one of the most prominent features in medicine, and opens a wide field of study and of practice to the physician.

Of the essential conditions of inflammation we know nothing; for we are no more able to assign the reason why a part should secrete lymph, or serum, or pus, than we are why the stomach digests or the liver secretes bile. All we are able to do is to determine the conditions necessary to the existence of this power, and to determine and to generalize its phenomena.

The conditions necessary to the existence of inflammation are one of two things, or else both conjoined, namely, a morbid action or condition of the nerves of the part, and also a morbid state of the fluids. Majendie has shown a morbid state of the nerves will produce inflammation, for he divided the fifth pair of nerves high up in the cranium, when the eye of that side, supplied by a branch of that nerve, inflamed and was destroyed. Again, if, instead of dividing the nerve, we make pressure on it, as by passing a ligature round a part, inflammation still takes place, the part separates into two, and the ligature comes away. Also, if from any cause the spinal cord be diseased, so that the nervous influence of the brain is interrupted and prevented reaching the lower portions of the body, the patient very constantly dies of inflammation of some part below the point of obstruction. It is plain, therefore, that a morbid state of the nerves is one cause of inflammation.

It is equally certain that a morbid state of the fluids will cause inflammation; for if we inject any putrid substance into the veins of an animal, the animal dies of inflammation of the lungs, or bowels, or other part; or if there be any other poison which produces inflammation, as arsenic, let it be injected into the veins of an animal, and it dies of inflammation of those parts for which the poison has an affinity. Majendie has likewise shown that a mere alteration in the proportions of the blood, as the lowering of its quality, is a cause of inflammation. Thus, he took blood from a dog, and having removed the fibrine, re-injected the serum into its veins, when the animal died of pneumonia, so complete that its lung having been laid by the side of one taken from a person that had died of influenza, their pathological states could not be distinguished from each other. Also the same physiologist found, on feeding animals on sugar, that the impoverishment of the blood thus produced was first manifested by inflammation and loss of its eyes. It is proved, therefore, that not only a morbid state of the nerves, but also a morbid state of the fluids, are conditions which, taken separately or together, often determine inflammation. The worst inflammations are those perhaps in which a morbid state of both exists. As a corollary from what has been stated, it may be affirmed, if inflammation is often of a sthenic character, and arises from a too powerful nervous re-action, that it perhaps more commonly arises from debilitating causes, and is of an asthenic character.

The diseased states resulting from inflammation of course will be found in the body of this portion of our subject. The generalization, however, of the phenomena of any science, and a statement of its more general laws, are the first steps towards understanding it. Celsus was the first who attempted to define inflammation, and he affirms a part to be inflamed when it is the seat of heat, of pain, of swelling, and of redness. But this definition appears to exclude much disease that can only result from inflammation; the brain, for instance, is often softened or hardened, or, as we believe, inflamed, and yet no redness is visible. A tooth is often destroyed by caries, and yet there is no swelling; the bowels are often ulcerated, and yet there is no pain. And Mr. Hunter has shown that the heat of an inflamed part never rises above the temperature of the blood in the heart, so that the heat of the abdominal and pectoral viscera when inflamed is not greater than that of a healthy part.

The definition of Celsus being inapplicable to some large classes of inflammation, it becomes a matter of consideration whether certain products, as serum, lymph, or pus, and also certain given states of parts, as ulceration, softening, induration, thinning and thickening of parts, would not afford a better criterion of inflammation than the abstraction of the great pathologist. If this view of the subject be admitted it would necessarily lead to a division of inflammation into *chromatous* inflammations and into *achromatous* inflammations, or into red inflammations and into colourless inflammations. Of the existence of the former there can be no doubt; and as a general principle the definition of Celsus well describes them, but the latter have no less a real existence. Thus we often open a patient that has died of phthisis and find the intestine ulcerated; but so far from being redder, it is paler than natural, and so far from being thickened, it is thinner than usual. We often find the cartilages of the joints ulcerated, and yet not a trace of a red vessel. In cases of bronchitis, with purulent expectoration, if the lung be washed so as to remove the morbid product, the most minute anatomist is unable to determine whether the parts during life were in a state of health or disease. Take the arterial system, and how often do we find the aorta thickened and thinned, softened and indurated, ulcerated and its elasticity entirely destroyed, and yet not a red vessel to be seen; neither has the patient complained of the slightest sensation of pain, or any feeling of heat in the part during life. A large abscess also may form in the brain or cellular tissue, or pus may be effused into the cavity of the abdomen, and without any appearance of redness or having been preceded by any suffering.

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There is no question, therefore, of the existence of achromatous inflammation, and this perhaps without any essential difference in the condition of the parts in either form of inflammation; for it seems determined, by the microscopic observations of Müller and others, that all vessels, however minute, carry red blood, but that those which admit one or at most two rows of red globules appear colourless to the unassisted eye. Whether, therefore, the inflammation be red or colourless, the same elements of the blood, though not in the same proportions, are employed in its development. If the division of chromatous and achromatous inflammations be established, a more correct definition of inflammation would be, that it is a state of parts in which the vital affinities are altered, giving rise to certain products, or states of parts: as the effusion of lymph, serum, or pus; or to ulceration, gangrene, thickening and thinning of tissues, &c.

### Of Chromatous or Red Inflammations.

Chromatous or red inflammation has many varieties as to kind. Thus we have Simple inflammation, Specific inflammation, Rheumatic inflammation, and many persons speak of a Scrofulous inflammation. These varieties differ in their causes, course, seat, and results, rather than in their phenomena, which it will be necessary now to present in a generalized form to the reader.

Chromatous inflammations, of whatever kind, may be acute or chronic, and have many degrees of intensity, denominated chiefly from their terminations, which are by resolution, by effusion of serum, lymph, or pus, or else by ulceration, gangrene, or mortification; and hence they are termed

| | |
|---|---|
| Inflammatio diffusa, | Inflammatio suppurativa, |
| Inflammatio serosa, | Inflammatio ulcerativa, |
| Inflammatio adhesiva, | Inflammatio gangrænosa. |

The order in which these different forms or intensities of inflammation have been named is the order of their intensity in some tissues, but by no means in all of them. In the serous membranes, for example, the progression is correct: the diffuse inflammation being less violent in degree than the serous, the serous than the adhesive, and the adhesive than the suppurative, and so on. But in mucous membranes this order is often inverted, for it is well known that lymph effused from the mucous membrane of the larynx is a much more dangerous and fatal disease than a secretion of pus from the same part. From this circumstance the same mode of inflammation often varies in danger and intensity in different membranes. Thus suppurative inflammation, when it occurs in a serous membrane, is fatal; but when it attacks a mucous membrane, as that of the urethra or lungs, it is comparatively of little moment.

Neither are all parts equally liable to all these different forms of inflammation; for the mucous membrane of the nasal fossæ, of the colon, and of the small intestines readily takes on serous inflammation; but serous inflammation is entirely unknown to the mucous membranes of the stomach and œsophagus. Purulent inflammation is common to the mucous membranes of the lungs, of the colon, and of the urethra; but is unknown as a secretion from the mucous membranes of the stomach or small intestines, without breach of surface. The same form of inflammation, therefore, has different values, and is of different frequency in different organs and tissues. It is consequently necessary to study the phenomena of inflammation, as it occurs in each particular organ and tissue. We shall now point out a few of the more particular laws, as well as some of the general laws incident to each form of inflammation, in whatever organ or tissue it may occur.

*Inflammatio diffusa* is an abnormal collection of blood in the capillaries of a part, disordering its functions, and sometimes, when affecting principal organs, as the brain, causing death. It has two stages; and the circulation being in general much increased in the first stage, that is termed the stage of *active congestion*. In the second stage the circulation is in general retarded; and this stage has been termed that of *passive congestion*. In the first stage the capillaries circulate arterial blood. In the second stage, they acquire the power of converting the arterial into venous blood, and ultimately of expelling the colouring particles of the blood altogether. After this they recover their healthy tone and function, and the inflammation terminates, as it is termed, by resolution, or without the escape of any morbid product. This mode of inflammation and its various phases are constantly to be witnessed in inflammation of the white part of the eye, as in conjunctivitis. Diffused inflammation attacks every organ and tissue of the body; has in all cases a destructive tendency, and has no reparatory power, except when artificially produced as a counter-irritant.

Many physiologists have sought to illustrate the difficult subject of inflammation by exciting diffuse inflammation in the webbed foot of the frog, and in the mesentery of the rabbit. It is doubtful whether the frog is an animal liable to inflammation, but the rabbit unquestionably is; and the phenomena observed have been, that the colourless capillaries of the healthy membrane become enlarged and filled with red blood; that the velocity of the circulating fluid is at first increased, but after a time, if the inflammation is violent, the velocity is gradually retarded in the centre of greatest inflammation, till at last the circulation becomes stagnant at this point, and this stagnation, or "*stasis*," perhaps at length extends over the whole of the inflamed surface. Again, if the inflammation subsides, the circulation is gradually re-established from the circumference to the centre, the healthy affinities of the part slowly restored, the arterial blood again converted into venous blood, and ultimately the colour, circulation, and functions of the part once more become healthy and natural. This is nearly all the information acquired by microscopic observations on the subject of the proximate state of parts in inflammation generally, for beyond this the tissue becomes thickened and opaque, and a veil is cast over the further processes of nature which it has hitherto been in vain to penetrate. It is remarkable that this proximate state of parts, as far as we can trace it, is the first stage, not only to the diffuse but to the serous, the adhesive, and the suppurative inflammations; so that those different forms of inflammation evidently depend on an altered affinity of the capillaries of the part for the fluids which circulate through them, rather than on any physical difference of structure demonstrable in the part itself.

Another fact relating to diffuse inflammation, as well as to the other forms of inflammation, has been determined, or, that the larger blood-vessels of the part are enlarged and contain much more blood than usual; again, should the part not recover its healthy state, the capillary vessels are nearly obliterated, or rendered im-

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pervious, since injections do not penetrate them as in health.

As a general principle, diffuse inflammation is said to terminate by *resolution*; that is, without any product whatever being effused; but this is not strictly correct, for when the inflammation has subsided the part is generally found thickened and opaque, some deposit having taken place either in its vessels or between their interstices. Much other injury is also usually done, for if a membrane be acutely inflamed, it is very readily detached, the cohesion of its connecting tissue being rendered extremely lacerable. Again, if an organ be acutely inflamed, it is rendered soft and easily torn: while on the contrary, if the same parts be chronically inflamed, the organ becomes indurated and the membrane strongly adherent. By these changes of cohesion the elasticity of parts, a circumstance often of very primary importance, becomes greatly altered and impaired.

In chromatous inflammations also the inflamed part has some shade of red; but this redness varies according to the tissue or organ. When, for instance, a serous membrane is inflamed, it is of a bright red or rose colour. On the contrary, if a mucous membrane be inflamed, it is of a deep red or venous colour, sometimes almost black; and though the colour of these parts is often represented as of a scarlet hue, this is probably owing to the part having been exposed to the atmospheric air before the draftsman saw it; for exposure to the air changes the original tint in a very few minutes to an arterial redness. It is perhaps owing to this latter circumstance that the conjunctiva of the eye and the mucous membrane of the mouth are generally of a bright red when inflamed. In like manner the liver, spleen, kidney, or other solid organ, when inflamed, is always of a deep venous hue.

When inflammation is of any intensity the functions of secretion and of absorption are greatly impaired. Thus, in diffuse inflammation the secretions of the part are stopped, and it feels dry, while its powers of absorption are so feeble that a strong poison placed in contact with the part either lies inert in it or is only slowly absorbed. These alterations of the powers of secretion and of absorption, though not so absolute as in diffuse inflammation, yet are common in a greater and less degree to all inflammations; and is a law by which we are enabled often to apply very stimulating applications, as mercurial ointments, to a diseased part without affecting the constitution.

*Serous* inflammation is when *diffuse inflammation* terminates with, or is attended with, *effusion of serum*, or of the more watery parts of the blood, the effused fluid, according to Kaltenbrunner, being thrown out in jets from the sides of the capillary vessels. This affection is for the most part destructive, though occasionally, as a counter-irritant, when excited by the action of a blister, its action is reparative. In *Serous* inflammation, even of a serous membrane, as the pleura, the fluid effused is not only greater in quantity than natural, but is also greatly altered in quality. In health the serous secretions are little more than a pure aqueous vapour, with a trifling addition of saline matters; but when they result from inflammation they contain a considerable quantity of albumen, sometimes a portion of fibrine, and at others pure blood, entirely unchanged in its physical properties. The quantity effused varies, according to the part affected, from perhaps a fraction of an ounce to a few pints, or even a few gallons. Serous inflammation is unknown as a disease of the liver, spleen, or kidney, of the bones or cartilages, or of the mucous membranes of the stomach or œsophagus.

*Adhesive inflammation* is when lymph is thrown out, or that portion of the blood which enters more particularly into the formation of muscular fibre. In surgery, if a party receive a wound, and the lips of the wound be immediately brought together, and the blood expressed—for the presence of much blood is inimical to the operation—a layer of lymph is thrown out, which becomes organized, forms a cicatrix, and the part heals by what is termed union by the *first intention*. Adhesive inflammation is so powerful in some tissues, that not only has a nose bitten off, or a finger chopped off, united, but even a large wound caused by amputation has frequently healed in two or three days, except where the ligatures were situated. In animals, even dissimilar parts will unite, as the testicles of a cock to the inner surface of the abdomen of a hen, or a spur removed has been planted on his comb. This property of adhesive inflammation is possessed by all organs and tissues in a degree sufficient to ensure union after division, and is the great agent on which the surgeon relies in all his great operations. In medicine, however, it is roused by a great variety of causes, besides mechanical accidents, and is always of a destructive tendency; for, effused into the substance of an organ or tissue, the diseased part becomes enlarged or thickened, giving rise to a large and formidable class of disease, little influenced by treatment. Again, if effused from the surface of a membrane, canals are obliterated; parts that should have motion are bound down, or else a false membrane forms, so prone to disease that the patient seldom long survives a most imperfect recovery. Considered as a diseased action, adhesive inflammation is possessed in very different degrees by different organs and tissues; thus lymph is often poured out in great abundance into the substance of the lungs, but in the liver, brain, spleen, or kidney, it seldom exceeds slight interstitial deposit. It is also frequently poured out in the greatest abundance from the serous membrane of the abdomen or chest, but it is infinitely less abundant from the serous membranes of the brain. It is common and abundant from the mucous membrane of the colon and larynx, but is hardly known as a secretion from the similar membranes of the stomach, œsophagus, or small intestines.

When adhesive inflammation takes place from a membrane, the lymph effused must act as a foreign body, inducing or keeping up a most destructive disease, unless it be removed or become organized. In serous cavities to remove it is impossible, and nature consequently adopts the latter process; first, as a means of fixing it and rendering it as harmless as possible; and again, by rendering it a living part to render it liable to be removed by absorption. The time of incipient organization after effusion is probably very short, and has been demonstrated by Mr. Hunter to have commenced as early as the 26th hour after the Cæsarian operation. Mucous membranes having an external outlet, the lymph effused can readily be removed, and has a ready exit. Nature, therefore, seldom induces the organization of lymph in these parts, but casts it out, so much so that organization of lymph, except in some of the smaller canals, is hardly known.

*Suppurative inflammation* is that process by which, in surgery, foreign bodies—a piece of detached bone, or

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a splinter, is removed from the system. In medicine it is always destructive, and may be either a further stage of the preceding inflammation, or it may exist *per se*. Pus, the peculiar fluid now formed, is globular, specifically heavier than water, has a sweetish mawkish taste, is of a peculiar odour, and is of a cream colour. This fluid varies greatly in quantity and quality in the course of the same or different diseases, being greatly influenced by the health of the patient; or it may be said to vary from a laudable pus to a mere ichorous sanies. Pus also, besides possessing certain chemical properties, may also possess certain specific animal properties: thus it may be impregnated with certain poisons, as that of syphilis, or of the small-pox; it is also often loaded with many foreign matters, as urate of soda, &c.

Pus, when secreted by a sound membrane, has no known beneficial property; but when secreted at the surface of an ulcer, or open abscess, it affords considerable protection to the tender granulations, acts as a temporary cuticle, and sometimes forms a crust, but not constantly so, under which the parts heal. The origin of pus is a peculiar action of the vessels of the part, by which the particles of the blood are converted into pus. Some physiologists have supposed pus to be the red globules morbidly changed and enlarged; but the quantity of pus poured out, often exceeding a pound weight a day, and this for many weeks or months together, renders this hypothesis impossible. Pus is consequently a new formation, and in some cases appears to be extensively absorbed. Andral has collected blood from the dead body and found globules of pus; so that it exists in the circulating fluid, under certain circumstances, is beyond all doubt.

Pus is daily seen to be poured out from a sound serous or mucous membrane, and from the surface of ulcers; but it may also be formed into an abscess, and the abscess may be either *phlegmonous* or *infiltrated*, and in the former case there are many different varieties or modes of formation.

A phlegmonous abscess is when the pus is collected into one cyst, and is prevented from escaping by condensation of the surrounding tissues. The formation of this kind of abscess is very various in different diseases. In the formation of phlegmonous abscess the vessels of the inflamed part are first injected with red blood proportioned to the violence of the disease; this blood at length bursts from the containing vessels, and diffuses itself throughout the inflamed portion of the organ, and combines with its tissues. The tumor now feels hard, but nevertheless its texture is tender, easily broken down, and, if the inflammation now proceeds, pus is poured out first in small *foyers*, but which at length unite and form the abscess, the red pulpy mass being either absorbed or else changed by an ulterior process into pus. If the abscess be now allowed to ripen, a membrane of greater or less tenacity forms, and lines the entire cavity; the functions of this membrane are not confined to containing pus, for it most probably imparts to that fluid an obscure vitality, and gives it freedom from putrefaction; it is also an organ of secretion, and of absorption, and by its means the quantity of pus is increased or diminished, and its quality rendered more or less healthy. This membrane is united by a close sympathy with the constitution, and feels in a rapid manner its slightest changes; for when enfeebled from any cause, the contents of the abscess from laudable pus often become an ichorous and offensive sanies; while on the contrary, if the health improves, an ichorous sanies becomes laudable or healthy in a most remarkable manner; in a few instances the contents of a large abscess are sometimes absorbed by this membrane.

The above description of an abscess is generally true, but it is certain, also, that this process greatly varies in different tissues, and even in the same tissue. No one, for instance, can fail to observe a striking difference between an abscess of the liver and that occasioned by a boil or carbuncle. In the former the parts have undergone a general softening, and are converted into pus; while in the other the process of *ramollissement* has been so partial, that a hard and solid core is amongst the first products discharged. A small-pox pustule is an abscess, but how different its phenomena from either of the former; first a hard tumefaction, then a vesicle filled with serum, and this is subsequently changed for or into pus; it seems therefore proved that the phenomena of phlegmonous abscess are not uniform in the same, and much less in different tissues.

When an abscess points externally, the solid parts forming the outward barrier are softened, thinned, and ulcerated, till at last nothing remains to oppose the escape of the pus except the cuticle, which at length ruptures and the pus is discharged.

The walls of a phlegmonous abscess, it has been stated, are always so condensed by inflammation of the surrounding tissues, that the pus is prevented from escaping. When, however, the pus effused is neither limited by a proper membrane nor by any condensation of the surrounding parts, it permeates the limb or organ by its own gravity, and is termed *a diffuse abscess*.

The incipient formation of the diffuse abscess is probably not dissimilar to that of a phlegmonous abscess, but as the inflammation is of a lower character all the processes are less complete; thus, no adhesive inflammation circumscribes the limits of the abscess, nor does any membrane form to contain the pus. The process of *ramollissement* is also imperfect, so that the abscess often contains shreds, or even large portions of mortified or loose cellular tissue. The pus secreted is also less healthy, is thinner, and less perfectly elaborated, containing a larger portion of serum, and oftentimes portions of loose lymph without a trace of organization. The pointing of this form of abscess differs also from that of the phlegmonous abscess, for the pus readily passes from its original seat by infiltration of contiguous portions of healthy membrane, and, gravitating towards the most depending position, presents a soft broad surface without any indications of pointing.

Such collections of matter are always of greater extent than phlegmonous abscesses, for the free transmission of pus from part to part occasions a great extension of the original disease. When these diffused abscesses are opened, the phenomena which result depend very much on the nature of the opening. "I have," says Mr. Hunter (note, p. 395), "seen large lumbar abscesses open of themselves, on the lower part of the loins, which have discharged a large quantity of matter, then closed up, then broke anew, and so go on for months, without giving rise to any disturbance: but when opened so as to give a free discharge to the matter, inflammation has immediately succeeded, fever has come on, and from the situation of the inflamed part as well as from the extent, death in a very few days has been the con-

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sequence." The same result has also occurred from opening *large* diffuse abscesses in other parts. In erysipelas, however, which so often gives rise to this form of abscess, a free opening is often necessary to allow of the escape of the portions of loose cellular tissue they contain.

Of *Ulcerative* inflammation there are three forms, as suppurative ulceration, serous ulceration, and dry ulceration. Most sores are instances of the first, the effects of a blister are instances of the second, and the last is sometimes seen in syphilitic maculæ, when a process of slow ulcerative absorption goes on without a trace of fluid of any kind being effused. All tissues are not equally liable to ulceration. The muscular tissues are less so than the adipose, and the adipose than the cellular tissue. It is from the operation of this law that abscesses sometimes point at very distant parts, as a lumbar abscess in the groin, and thus many important parts are for a time saved.

*Granulation* is an union of parts by "second intention," and is always reparative. Granulation has two forms, or granulation with suppuration, and granulation without suppuration. The first is extremely common. The latter is occasionally seen in the healing of syphilitic maculæ; and Mr. Hunter conceives he once met with it in the union of a broken thigh-bone.

Granulation, according to Mr. Hunter, results from an exudation of lymph, into which old vessels extend, and new ones are formed, and a new surface results, which is "granular"—the granule, in the opinion of modern physiologists, being a small conical tumor, or growth, composed of a mesh of terminal loops formed by the capillary vessels shooting into the effused lymph. The figure and colour of the granulation, says Mr. Travers, are determined by the state of the circulation; when that is feeble and inclined to stagnate, the granulation is broad, flat, and spongy, and either pale or of a livid hue; when, on the contrary, it is vigorous, the granulation is conical or acuminated, and of a bright red tint. The vessels prolonged into the granulation are more or less tortuous, and so numerous as to require a high magnifying power to exhibit their distinctness after successful injection. These vessels become contracted to obliteration as the period of cicatrization approaches. Granulation may take place from a surface, or from the sides of an abscess. If from the cutaneous tissue the sore heals by a process of skining; the skin, according to Mr. Travers, always springing from the edges of the wound, even in cases when the new tissue first appears in the central parts. Again, if granulations spring from the walls of an abscess, their opposite surfaces for the most part unite. Granulations sometimes form most rapidly, for Mr. Hunter has seen, after trephining a patient, the dura mater strongly united to the scalp in 24 hours. Granulations, however, have not in all cases an equal disposition to unite. Thus the granulations of fistulous abscesses are little prone to adhere, their surfaces being often as difficult to unite as those of a mucous membrane; indeed it is often impossible to produce adhesion except by exciting a considerable inflammation. A part having healed by granulation uniformly contracts. This contractile force is so great that although the sore made by the amputation of a thigh is seldom less than seven or eight inches in diameter, yet the cicatrix left on healing is hardly more than a crown piece. It is from this cause that we always find in viscera that have been the seat of abscess a marked depression at the point of cicatrization.

With respect to the granulations themselves, there is no question of their being furnished with nerves, absorbents, and secretory vessels, for the part is pained when touched; pus and lymph are secreted, and poisons, as mercury or arsenic, are absorbed by them; and although they are not powerfully absorbant, yet such quantities have sometimes been taken up as to have caused the death of the patient.

The reproductive energy of granulation, however, is not great, for it is rare that the original tissue is reproduced. No fat, for instance, is regenerated in ulcerated adipose tissues; a muscle being divided unites by a cellular cicatrix, no muscular fibre being reproduced, and a divided cartilage unites by a ligamentous, but not by a cartilaginous tissue. The skin, when destroyed, may be reproduced, yet generally it is imperfect, for after small-pox the rete mucosum is either slow in forming, or never forms at all, so that the pit remains whiter than natural. The reparation of the mucous membrane is equally imperfect, the villi being always wanting. The reparation of a flat bone, as the cranium, is so slow that 10, 20, and even 50 years pass away before a small trephine hole is filled up with bony matter. In like manner a healed cavity of the lungs is always marked by a cicatrix of cellular tissue, altogether different from the original structure; neither, as far as we know, is the fibre of the liver, of the spleen, or of the kidney restored. It is doubtful whether a divided nerve is ever united by nervous matter; many pathologists think not, but conceive that when a part has recovered its sensation or motion, after such an operation, that a cellular cicatrix of extreme tenuity forms, through which the nervous fluid can penetrate,—that fluid, like electricity, having possibly a striking distance.

It is a law also of all cicatrices, that the newly formed part is harder and of greater density than the original structure. Muscle, for instance, unites by coarse, dense, cellular tissue; tendon by bone; and bone after a fracture is a more compact substance, and contains more phosphate of lime than before the accident; but, notwithstanding this addition, the new bond of union is not so strong, nor the living principle so energetic, as in the original structure; for when the constitution has been enfeebled by severe disease, an old sore has been known to open, and the ends of a once broken bone to separate. It is equally a law that a part having been once inflamed, the liability of the part to that form of inflammation is greatly increased; and also when new membranes or tissues have formed, that these tissues are infinitely more prone to every form of disease than the original membrane.

*Mortification* is the death of a part, and may be complete or incomplete. In the soft parts the former is termed sphacelus, and the latter gangrene; while in hard parts, as the bones, there is a similar distinction, or into caries and necrosis.

Mortification of the soft parts may be white or black, humid or dry. Black mortification is when the venous blood is extravasated through the walls of the blood-vessels into the affected tissues, giving to the part a purple or black appearance, while to the touch it is soft, inelastic, and doughy. White mortification is when, by the action of cold, the blood has been driven from the part, and the part subsequently freezes perfectly white; but,

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although frozen, the vitality of the part is not destroyed, for it can be recovered by proper treatment; on the contrary, if the treatment be indiscreet, as warmth suddenly applied, it thaws, re-action takes place, the part becomes immensely swollen and inflamed, and is ultimately destroyed.

*Humid* mortification is when the blood transudes in a fluid state, and after its exudation probably separates into its constituent parts, so that the serum set free raises up the cuticle in bladders, forming what are termed phlyctænæ: air is also not unfrequently contained in the phlyctænæ, generated by a process of commencing putrefaction, giving to the finger touching the part a sensation of crepitation.

*Dry mortification* is a rare disease, and is supposed to be caused chiefly by the ergot of rye, but this is probably an error. In the year 1716, dry mortification appears to have been to a certain extent epidemic at Orleans, 50 cases having been treated at the Hôtel-Dieu of that city. Dodard has described it as beginning generally in one or both feet, with pain, redness, and a sensation of heat or burning like that produced by fire. At the end of some days the part became cold, as black as charcoal, and as dry as if it had been passed through fire. Sometimes a line of separation was formed between the dead and the living parts, and the complete separation of the limb was effected by nature alone, and in one case the thigh separated in this manner from the body at the hip joint. In other cases amputation was necessary. Mr. Solly has given an interesting case of this description, which occurred in the practice of Mr. Bayley, of Odiham. The party was a child 3 years and 7 months old, from whom both arms were removed, by this spontaneous process of nature, above the elbow, the left leg below the middle of the thigh, and the right foot above the ankle joint, being a remarkable instance, in modern times (*R. M. C. Trans.* vol. xxii. 23), of this destructive disease.

The bones, the brain, the lungs, the liver, the spleen, and the kidney, are all liable to sphacelus and gangrene; so are the different tissues, as the cellular and cutaneous tissues, the nervous and serous tissues. The muscles, tendons, aponeuroses, and blood-vessels, are likewise all liable, but in a less degree, to these formidable affections, which are sometimes the effect of inflammation, and again are in some instances idiopathic.

The pathology of the soft parts has been carefully studied in mortification, but little more has been discovered than what has been stated, or extravasation of blood, and its coagulation in the capillary, as well as in the larger vessels, together with great softening of the tissues of the part. The extent to which the coagulation extends in the large vessels is often great; for incisions made during life, four inches above the apparently dead parts, have in some instances not been followed by hæmorrhage.

### Of the Constitutional Effects of Chromatous Inflammation.

There is so close a sympathy existing between the different organs and tissues of the body, that the functions of one being subverted or disturbed, the rest more or less generally fall into disease. Every local inflammation, therefore, of any intensity creates a shock which deranges remote and distant parts, and which is termed the *constitutional* affection. In the present state of medicine it is impossible to unveil the mysterious laws of the nervous system by which the different effects are conjoined, but some authorities suppose the morbid impression is transmitted by the nerves of the part, in slight cases, to the nearest nervous centre, in severe ones, to the brain, whence it may be transmitted to the system generally, causing headache, nausea, or diarrhœa, phenomena which they imagine to be caused by a simple affection of the solids. On the contrary, there are other physiologists who conceive these same phenomena to be caused by matter absorbed from the wound, and therefore to result from a contamination of the fluids. All theory apart, however, the constitutional affections may be limited to a mere affection of the pulse; to a disturbance of the alimentary canal, causing loss of appetite, sickness, diarrhœa, or constipation; to an affection of the liver, or of the brain, or chord, as when a trifling wound is followed by tetanus. These sympathetic affections, however, whether taken separately or conjoined, do not denote any particular form of inflammation, neither do they mark any particular seat of inflammation, for a whitlow is as likely to produce any or all of them as an abscess of the liver. There is one law, however, which ought not to be passed over, which is that remarkable difference of pulse which exists between severe inflammation of a serous or of a mucous tissue; or in the former it is small and extremely rapid, while in the latter it is perhaps natural, or but little accelerated.

When the constitutional affection is general and produces fever, the fever may precede the local inflammation, or it may occur at some subsequent period. In the former case it will ultimately be found in all probability that the cause of the fever is a morbid poison, and if so, the latter instances will form the only true cases of sympathetic or symptomatic fever. Assuming then the symptomatic fever to follow the inflammation, it may occur at two different periods, or shortly after the attack of inflammation, or immediately before suppuration takes place.

Symptomatic fever has a distinct connexion with the local disease, for that being healed it immediately subsides. It does not, however, necessarily mark any peculiar form or degree of inflammation, for the fever which ushers in an erythematous eruption is often as considerable, or even more so, as that which accompanies a fatal pneumonia or hepatitis. The same form of inflammation, even in similar membranes, is attended with very different degrees of fever. Thus serous inflammation of the pleura, or of the peritoneum, is seldom accompanied by much fever, while sero-arachnitis is very constantly so. Again, adhesive inflammation of a serous membrane, as the pleura, is often accompanied by some fever; but lymph poured out from the mucous membrane of the larynx, as in croup, or of the colon, as in some forms of diarrhœa, is seldom accompanied by fever.

When inflammation is established and proceeds to suppuration, a severe paroxysm of shivering is often the first indication of the formation of the abscess, or of the effusion of pus, but the degree of symptomatic fever varies greatly even in this case, for a most copious secretion of pus may take place from a mucous membrane, as that of the bronchi or urethra, and the constitution hardly suffers from any appreciable degree of fever, while a trifling amount of pus from a serous membrane is often followed by fever of a fatal character.

In any case the character of the fever depends on the constitution of the patient, for if that be good the fever is attended with a white tongue, much heat, a full and strong pulse, and with little tendency to a brown tongue.



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On the contrary, if the patient's constitution be broken, the fever is of a low type. In the event of an abscess forming, the fever is often sthenic during the earlier periods of the inflammation; but as soon as the abscess ripens, if any important organ is its seat, the fever becomes asthenic, with a brown tongue and a rapid pulse, while the local pain in a great measure subsides. At this period the abscess must open either spontaneously or by art, or otherwise the patient for the most part dies. The opening of the abscess, though attended with much pain from the contracting of the inflamed walls, is usually followed by great relief of all the constitutional symptoms, and the pulse rises, the tongue cleans, the appetite returns, and a visible and immediate amendment takes place. If however the patient has been exhausted by his sufferings in the earlier stages of the disease, the relief afforded is but transient, the pus secreted degenerates into a sanies, or is altogether suppressed, the fever changes to typhoid, and the patient sinks, too enfeebled to establish the reparatory process.

It is remarkable, however, that a patient who would be destroyed by a continuance of the suppurative inflammation is often preserved by substituting a process of adhesive inflammation, or of union by the first intention, for that by granulation, or by the second intention, showing that the part is often in one state while the constitution is in another. It is upon this principle the surgeon acts in amputating after a severe compound fracture, or for intractable suppurating diseases of the joints, the constitution having the power to heal a simple wound, though not a suppurating one.

Another law of inflammation is, that for the most part an interval more or less long elapses after the application of the cause before the occurrence of either local or constitutional phenomena. A patient, for instance, receives a violent concussion of the brain; in a short time he recovers himself, and is able to walk home; but a few days after he is seized with arachnitis, or other local inflammation. A person, after being exposed to cold or wet, seldom suffers an immediate attack of inflammation, but the next day, or two or three days after, inflammation of some organ or viscus is established, and the lapse of a similar interval takes place after the application of any other cause.

When the constitutional affection or fever assumes an intermittent type it is termed "*Hectic*." The paroxysm of hectic usually comprises three stages, or a cold stage, a hot stage, and a sweating stage, but in many cases one or even two of these may be wanting. The cold stage, for example, may be followed by the sweating stage, and this is the cold clammy hectic which patients so much dread; or it may be composed of a hot stage, followed by a sweating stage, which so constantly takes place in the morning in phthisical patients; or the paroxysm may consist of a hot and cold stage, or of a hot, or a cold, or a sweating stage only.

Hectic fever is usually supposed to designate a chronic abscess, and especially an abscess of the lungs; still, it often accompanies chronic disease of the liver, or spleen, in which no suppuration is present. Mr. Hunter has laid it down as a law in surgery, that the further a diseased part is from the source of circulation, the earlier this constitutional affection is formed; or that it occurs sooner when the ankle or wrist joint is affected, than when the hip or shoulder joint is the seat of a similar disease.

*General rules of treatment in simple Inflammation.*—The great remedies we possess in subduing simple inflammation are bleeding, certain medicines, and topical remedies. The medical treatment of inflamed parts varies greatly according to the organ or tissue affected, and will be best treated of under each respective head of Inflammation, but it may be proper to say a few words about bleeding.

Bleeding, by diminishing the quantity and altering the quality of the blood, has a direct tendency to reduce the excitability of the nervous system, and thus to abate the action of the heart and arteries; and if inflammation were merely an increased action of parts, we should only have to apportion the quantity of blood drawn to the increased force or power to cure the disease. Nevertheless, we find in practice that this most powerful of therapeutic agents in the cure of inflammation often requires the greatest caution in its employment; for there is a line beyond which bleeding becomes destructive instead of remedial; and consequently it seems to follow, that in a great number of cases inflammation is something more than increased action. Some general rules are therefore necessary to guide us in the use of the lancet; and none perhaps are of more importance than that its utility varies according to the nature of the cause, the organ affected, and the state of the blood.

There is no truth, perhaps, in medicine more conclusively determined than that we ought not to bleed, or to bleed sparingly, when the inflammation depends on a morbid poison. In epidemics, therefore, of every kind we should not hastily have recourse to the lancet, but should remember the disease probably depends on a poison, has a course to run, and is not amenable to the mere abstraction of blood. Again, the nature of the membrane or organ affected must always be considered in estimating the propriety of bleeding. If a serous membrane, for instance, be acutely inflamed, the patient, for the most part, bears bleeding well, and is usually greatly relieved by it. Inflammation of mucous membranes, however, though occasionally relieved by bleeding, is seldom cured or even greatly influenced by that operation. Another law also which experience has determined is that, as a general principle, diseases of the skin bear bleeding badly, and even when most acute, the patient often sinks if a large quantity of blood be taken. With respect to organs, likewise, it is found that inflammation of the brain is less influenced by bleeding than inflammation of the liver, and inflammation of the liver than inflammation of the lungs.

The next consideration is, what indications for bleeding are to be drawn from the state of the blood? In the great class of febrile diseases, says Andral, the fibrine never augments, remains often in normal quantity, and is also often diminished. In the phlegmasiæ, on the contrary, there is a constant augmentation of this principle; the fibrine being in excess compared with the red globules, and instead of being 3, as in health, oscillates between 4 and 10. It is this excess of fibrine which gives firmness to the clot, and is the cause of its being buffed and cupped. The immediate effect of bleeding, according to the same high authority, is to reduce the red globules instanter, but not so with the fibrine; for a reduction of fibrine does not take place till after a certain time, bleed as you may. Such is the state of the blood in the phlegmasiæ. There are many reasons, however, for not esteeming the buffed and cupped state of the blood denoting an excess of fibrine as a sufficient warranty for bleeding; for these conditions are often pre-

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sent in erysipelas, phthisis, or the early stages of typhus; and in either case the loss of a moderate quantity of blood might hurry the patient to his tomb. Again, in acute rheumatism the blood is not only buffed and cupped, but contains a maximum quantity of fibrine; yet the best practitioners seldom think it necessary to take blood, considering that mode of treatment as neither affording present relief, nor shortening the course of the disease. The fact, then, of the blood being buffed and cupped does not, in all cases, warrant venesection; indeed it is calculated that three-fourths of the victims of mala praxis perish from deducing the rule of treatment solely from the state of the blood. "Bleed daily as long as you see the blood inflamed," was the direction of a naval surgeon to his assistant. The order was strictly obeyed, and thus, adds this gentleman, "I sent many a brave fellow to a watery grave." It follows, then, that in addition to a given state of the blood, certain symptoms must also be present, as well also as the probability of a certain cause, to induce us to bleed largely in inflammation.

There are many circumstances, therefore, which prevent the blood from being an unerring guide for bleeding in cases of inflammation. Still, the blood does offer certain therapeutic indications either for bleeding or not bleeding when the symptoms would otherwise demand or forbid this operation. The firmness of the coagulum, for example, has been considered, at all times, as a mark of the tonic state of the system, and as a warranty for repeating the bleeding when the part is as yet unrelieved; while, on the contrary, a looseness of texture is a sure sign of great debility, so that unless other circumstances strongly indicate the necessity of bleeding it ought not to be repeated.

The proportion of the serum to the clot, and also its occasionally altered characters, are arguments also for or against bleeding. When the quantity of serum is unusually large, unless the clot be very firm, bleeding ought not to be repeated. Also when the properties of the serum are so altered that it coagulates and forms one mass with the clot, bleeding is constantly prejudicial; and lastly, it has been observed, that when the serum, which has little or no affinity for the red globules in health, readily dissolves them, that this is an unerring sign that further bleeding should be avoided, unless no hope remains of saving the patient by any other means.

It is well known that the sthenic or buffed characters of the blood are often greatly modified by the manner in which the blood is drawn; thus, if an individual be bled in both arms, but the blood allowed to flow with different velocities, or in a full stream from one and slowly from the other, the blood drawn is identically the same, yet a thick buff will be wanting in the latter, and be present in the former. Also, if the apertures be of different sizes, the same differences will result; or the blood from the larger orifice will be buffed, while no such effect is seen in the blood drawn from the smaller one. Again, the form of the vessel which receives the blood, as whether it be flat or conical, and also its temperature, or whether the blood be received into one that is cold or warm, will also affect the phenomena of its coagulation. In this difficulty, Mr. Thackrah has furnished us with a most useful rule to correct the error, or to observe the time of the coagulation of the blood. Everything that tends to debilitate the body, or to exhaust the nervous energy, facilitates the coagulation of the blood; or supposing it takes five minutes for blood to coagulate in health, if the patient faint, it will coagulate in two minutes.

In brutes the force of coagulation increases in proportion as the powers of life are impaired, and often in a striking manner; thus, the last portions of blood that flow from a slaughtered animal, as the ox, coagulate much more rapidly than that which follows the knife. If blood also is taken from a dog when he shows much alarm, it coagulates almost immediately. But the most striking proof is perhaps given by Fontana, who found that although the poison of the viper, when mixed with blood recently drawn, does not affect the time of coagulation, still that this substance injected into the veins of a rabbit caused instant coagulation, followed by the death of the animal. It seems, therefore, proved that the time of coagulation is diminished in proportion to the debility of the animal.

### Of Achromatous Inflammations.

Achromatous inflammations, or those in which we find the effects of inflammation or its products without any trace of redness, form a class of diseases which, though numerous, has hitherto been little studied. They have no stage or form corresponding to diffuse inflammation, but consist of serous inflammation, which, when it affects organs, as the brain, has been termed Malaxoma, and is the ramollissement of the French, of adhesive inflammation, including hardening of parts or Scleroma, and also the purulent ulcerative and gangrenous inflammations, and these may be either acute or chronic.

*Serous achromatous inflammation* is very constantly met with in the abdomen, the peritoneum being of a silvery whiteness, opaque, and greatly thickened—effects evidently the result of inflammation; its cavity also is at the same time filled with turbid serum, sometimes containing portions of fibrine. The more remarkable form, however, of achromatous serous inflammation is when it attacks the substance of an organ or tissue, oftentimes rendering it whiter and softer than natural; and in some cases, so loaded with serum as to be almost diffluent, and hence termed malaxoma or ramollissement. Thus, in fever, or after a severe blow on the head, the brain, or some portion of it, is often unnaturally white and exceedingly soft; a state of parts unquestionably the result of inflammation, for the symptoms most commonly are extremely violent, while the membranes are found in every state of inflammation, and adherent generally to the diseased portion of the brain. The same achromatous state of inflammation is frequently met with in a more chronic form; and in many instances the brain is so soft that serum can be expressed from it in considerable quantities. Ramollissement equally attacks the spinal cord, the tissues of the alimentary canal, the heart, the muscles, liver, spleen, and indeed all the organs and tissues of the body.

*Achromatous adhesive inflammation* is marked by the directly opposite phenomena of malaxoma, or of induration or *scleroma*. Thus the brain or chord is occasionally found as hard as blanche mange, or the white of egg boiled hard; a morbid condition which seems hardly explicable on any other ground than the assumption of a colourless inflammation, for not a trace of a red vessel is to be seen. We also often find the tubuli of the kidney almost cartilaginous, and yet not the slightest injection. It is probably owing to this mode of disease, that adhesions and false membranes



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are so often formed in the chest and abdomen, not only without the slightest consciousness of disease on the part of the patient during life, but without any appearance of a red vessel after death. If this law be admitted, we must attribute to it the many enlarged and hard spleens, livers, and kidneys. Many old chronic cases of gout or rheumatism of the joints are probably of this character, as well as syphilitic nodes of the bones.

*Achromatous suppurative inflammation* is often met with on the backs of soldiers on a march, the weight of the knapsack causing abscesses to form at the points of greatest pressure, but these abscesses often form without pain, heat, or redness. We also sometimes find a large abscess in a pale liver, and not a red vessel to be seen. In the lungs also grey hepatization and abscesses around tubercular matter are constantly seen, and yet no sign of increased redness or vascularity. In the brain also abscesses of a similar white formation are sometimes met with. In mucous membranes similar achromatous inflammations are very common: pus is often secreted from the bronchial membrane, the colour of the membrane being natural; and who has yet been able to decide whether a woman does or not in many cases labour under gonorrhœa—the parts in this disease seldom presenting any alteration of colour? The same absence of redness is also occasionally seen of the pericardium or peritonium, those cavities being full of pus.

*Achromatous ulcerative inflammation* is seen in many instances. No more strenuous battle has been fought by anatomists than whether cartilage is or is not endowed with organic life. Since, however, we observe cartilage swollen and softened, indurated and thinned, and often extensively ulcerated, no doubt can exist of its vitality; yet to the naked eye, in all these diseases, there is not a red vessel visible. In phthisis we often find the plaques de Peyer ulcerated, and yet the membrane is paler than natural; bones and cartilages are often destroyed by ulceration, the parts being so pale that Mr. Hunter has termed it interstitial absorption.

Even some forms of mortification are achromatous, as the mortification in frost-bitten parts, and to which we have before referred; but taking all these forms of achromatous inflammation together, the best and most striking examples are to be found in the proper coats of the arteries, which are often thickened and thinned, softened, indurated, and ulcerated, with an entire achromatous state of the parts. It is probably owing of the existence of some of the preceding forms of disease that we owe the formation of cysts, and of the states of hypertrophy and of atrophy.

*Cysts* are occasionally formed in all parts of the body, as in the brain, the lungs, liver, spleen, or kidneys. They are also common among the bursæ, in a mucous follicle, a Graafian vesicle, and the cells of the parenchymatous tissue generally. The formation of these cysts depends probably first on an achromatous serous inflammation, followed by an altered balance of secretion and absorption. The cyst once formed, the globule of serum, instead of being absorbed, is multiplied, thus making a pressure which enlarges the cyst, whose walls become thickened by a continued achromatous adhesive inflammation. These cysts are of various sizes; and in the interior of the mouth, or along the edge of the tarsi, they are seldom larger than a pea; in the brain they are sometimes met with as large as a pigeon's egg; while in the ovarium, where they attain their largest magnitude, they often contain two, three, or more gallons. When small, the cyst is generally single; but when of great size, it is more commonly, especially in the ovary, multilocular, the tumor being composed of five or six, or more different cysts. These cysts are liable to inflame and become cancerous, and the seat of tubercular formations.

The external membrane of these cysts is very various, often transparent, thin, and delicate; but in other cases opaque, dense, of considerable thickness, occasionally cartilaginous, and in rarer instances ossified. Their contents are even more diversified than their structure, being generally serum, with little foreign matter; but at other times mixed with large portions of albumen, either in solution, thrown down in flakes, or otherwise precipitated. At other times the contents resemble honey and water, while, if they inflame, we often find lymph, gelatiniform matters, pus, and sometimes a dark fluid, like chocolate or coffee grounds, evidently discoloured by a morbid state of the colouring particles of the blood. The contents of these tumors are sometimes still more remarkable, for when situated in the scalp they sometimes burst, and a secretion in a semi-fluid state exudes and concretes into a dense substance, having the appearance of a horn curved and tortuous, and much resembling those of the inferior animals. These horns, termed plica Polonica, have measured nine inches in length, and from two to three in circumference, and may be removed with the knife with impunity.

The most singular of all the varieties of these tumors is that which, instead of containing the matters which have been mentioned, sometimes contains teeth or hair. Thus Mr. Barnes found in a double encysted tumor of the orbit both teeth and hair. Lobstein gives the case of a man, aged 50, in whom in the course of three months a cyst formed, which, being opened, contained three teeth, each in a separate cyst. In another case, in a cyst connected with the abdominal diaphragm, fat, hair, and four teeth were found. Rysch found four teeth in a tumor of the stomach. These instances might be largely multiplied, and their most frequent seat is the ovary, of which an instance occurred in St. Thomas's Hospital only a few days ago. The encysted teeth are formed according to the same laws as ordinary teeth. They arise from isolated capsules filled with a gelatinous fluid, and if by chance the osseous portion is wanting, the gelatinous is present. Like ordinary teeth, the crown is formed before the root. When there is more teeth than one, their growth is not always simultaneous, for some are yet germs; others milk teeth, while others are the perfect second teeth, and in some cases the milk teeth are found to have been replaced by second teeth. Molar teeth are more frequently met with than incisors; but in all instances the teeth found are similar to those of the animal generating them.

The hair also found growing in these cysts varies in length from two or three inches to twenty or thirty; has always a bulb and root similar to hair of ordinary growth, and may be black, red, brown, or grey, and two or more of these colours have been found in the same cyst. These cysts are said to be lined with cuticle, which may desquamate, and they generally contain some atheromatous matters. Hair has also sometimes been found growing from the surface of membranes, as from under the tongue; from the mucous membrane of the gall-bladder, or bladder, and from the testicle.

Besides the serous cysts which have been mentioned, there is a class of vesicles or serous cysts, which are

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Elementary Principles of Medicine.

supposed to have an independent life, and are termed hydatids. There are several genera of this kind found in animals, but two only appear to be peculiar to man, or the cysti-cercus and the acephalo-cystis. The cysticercus has a head somewhat resembling that of a tænia, and a nearly cylindrical body, terminated by a caudal vesicle, and generally exists singly. Dr. Sharpey states he has repeatedly met with them while dissecting at Berlin. The acephalo-cystis, however, is that which is most frequently met with in man, and these have neither head, neck, or visible extremity.

The coat of the acephalo-cystis is a serous membrane of great tenuity and delicacy, so as to be almost transparent, and only, in a few instances, is it opaque or dense. It contains an aqueous fluid nearly pure, and in size varies from less than a pea to a goose's egg. The acephalo-cystis, when it acquires even a very moderate size, often contains a number of smaller hydatids, and these again may contain others of less magnitude than themselves, like a child's nest of boxes. Taking them collectively, they often exist in large numbers; the abdomen in some cases of ascitic dropsy containing many hundreds or thousands. Of the generation of these parasitical animals we know nothing, neither are they supposed to be of long life, for in the pig, if generated in the spring, they appear to die in the autumn, while in man it is doubtful if they live a twelvemonth. The vitality of these cysts, however, is very obscure, its only proof being that they are said to have contracted when thrown into hot water, but even this indication is often wanting.

These animals affect every part of the body, as the brain, spinal cord, the substance of the lungs, the cavity of the chest, the liver, spleen, pancreas, and kidney; the cavity of the abdomen, the tonsils, the uterus, the bladder, the muscles; while sometimes they are embedded in the substance of the bones.

Such are some of the forms and modes of *achromatous* inflammation, which, taking them altogether, form a most extensive class of disease, and contribute in a large proportion to the general mortality. If we look to their causes we shall find in them every error of diet, and all those unhealthful circumstances which congregate about men living in towns and cities. They are for the most part secret in their course, form without pain, and are only denoted at first by occasional disordered action of the part, which increases in frequency till at length the associated viscera and then the constitution take the alarm. The constitutional symptoms are not so uniform nor so marked as in chromatous inflammations; but still they have in many instances a general resemblance to each other, and are greatly more fatal. Has the patient a diseased valve of his heart, he for the most part dies of dropsy; has he an enlarged and otherwise diseased liver, he becomes dyspeptic, perhaps jaundiced and dropsical; has he a diseased spleen, he suffers from dropsy, and generally dies of hæmorrhage. It is in this class of disease that our remedies are so inefficient, and the practitioner will deserve great honour who shall be fortunate enough to discover medicines which may diminish their fatality.

### Of Hypertrophy and of Atrophy.

Hypertrophy and Atrophy are among the most frequent phenomena in pathology. Hypertrophy is an abnormal enlargement of the organ or muscle without any apparent change in its healthy structure. Considered pathologically, however, the functions of a healthy organ so enlarged are seldom healthily performed, for an abnormal increase of the powers of the heart uniformly destroys the natural balance of the circulating forces, and ultimately leads to the death of the suffering party. Again, an enlarged liver, even when most healthy in appearance, is for the most part followed by jaundice and dropsy; while a patient labouring under a hypertrophied heart generally suffers from palpitation and asthma, and ultimately falls perhaps from apoplexy or dropsy. It is certain, also, that most hypertrophied organs are for the most part abnormal as to form, the hypertrophied liver being generally enlarged only at its left or at its right lobe. The hypertrophied heart is also generally misshapen, pouchy, the strength of the walls of its different cavities disproportioned to each other, while the capacity of its chambers are of different and of abnormal content. In some instances, as in double organs, the law of hypertrophy is reparatory. Thus if one kidney be atrophied the other usually becomes hypertrophied, and its power of secretion proportionally increased; yet this organ is more likely to become deranged than when the usual provision of nature for the performance of the urinary function is perfect. In like manner, we see the muscles of the leg by exercise acquire a power which may rupture the tendon Achillis, or even snap the bones of the leg asunder. Every organ, even the brain itself, is liable to become hypertrophied, and so is every tissue. More commonly the hypertrophy of tissues is partial, as warty growths from the skin, exostosis from the bones, polypi from mucous membranes, and more particularly a morbid deposition of fat in the adipose tissues. We will now point out some of the more remarkable circumstances connected with the two latter forms of disease.

Polypus is a common species of tumor usually attached to a mucous surface. The simple mucous polypus has a shining appearance, being invested by an extremely delicate membrane resembling a mucous membrane, and moistened apparently by a mucous secretion. It is of a soft consistency, homogeneous in structure, and generally of a semi-transparent light brown colour. In shape it is pyriform or clustered, one or more being suspended from a narrow pedicle or stalk. It seldom attains a large size, possessing but little vascularity, and is nearly devoid of sensibility. The seat of polypi is more especially the nose, uterus, bladder, larynx, œsophagus, stomach, and colon. Fibrous tumors also sometimes spring from the dura mater.

Polypi often become malignant from cancerous deposition, and in this case the disease extends not merely to the mucous membrane, but also to the surrounding parts. Most frequently it is encephaloid in character, and presents a cauliflower appearance, its surface being studded with numerous excrescences of medullary consistency.

Sometimes the adipose tissue is alone hypertrophied, or the seat of *Steatoma*. The person generally in childhood and in advanced age is liable to an embonpoint or increase of fat; but this increase of fat is sometimes a disease, and appears in parts not naturally its seat, and many organs and tissues are consequently capable of undergoing this fatty transformation or *steatoma*.

The muscles are the organs most liable to this transformation, and not merely to a simple accumulation and interposition of fat between the muscular fibres, but these

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fibres themselves are sometimes converted into steatomatous substance. The muscles of the lower extremities are more disposed to a fatty degenerescence than those of the upper, and we can sometimes trace the progress of this transformation, for by the side of fibres which still preserve their natural appearance, we often see others that are white, and also other fibres which have already experienced the steatomatous conversion. The heart is also occasionally seen to have more or less generally undergone this degenerescence, and, strange to say, is sometimes converted into little more than a soft fatty membrane.

The liver, especially in phthisis, is often found to be loaded with fatty matter, or the seat of steatoma. In this case it is of a pale yellow colour,—preserves the impression of the finger, and, according to Vauquelin, has been found to contain as much as 45 parts of a yellow concrescible oil, greasing the scalpel, and causing paper smeared with it to burn as if dipped in oil.

The kidney is also often liable to this fatty transformation. Dupuytren and Lobstein have both seen the pancreas converted into fat, while Sir Astley Cooper found much fat in the substance of the lungs of his late Majesty George the Fourth, and fat has also been observed in the ovary and testicle.

The membranes are also occasionally the seat of steatomatous tumors; thus Mr. Abernethy found a portion of fat hanging pendulous from the surface of the peritoneum, and several instances are recorded of stearine having been found in the arachnoid. Some short time ago a fatty tumor was observed in a subject examined at St. Thomas's hospital hanging pendent from the mucous membrane of the intestinal canal.

When we observe how extensively the steatomatous conversion prevails, we may infer that under certain conditions of the animal economy it is probable it may take place in all tissues and organs. Its most common seat, however, is the integuments of the body, which may be general, as in the case of Daniel Lambert; or it may be partial, forming a greater or less number of fatty or steatomatous tumors. These are ordinarily pediculated, and have sometimes four or five roots of unequal length; and it is by these pedicles that the vessels are introduced. They are often encysted, and are inconvenient only from their size. The extent to which they may occur may be seen in the following case, taken from the *Revue Médicale*:—The patient was a young woman in good health, but who, although thin and of the middle size, weighed 169 French pounds. Between her shoulders were two adipose, or fatty tumors, 8 inches long and 3 inches broad; a third, of less size, was situated near the arm-pit; and a fourth arose from the inferior angle of the shoulder blade, and was 15 inches long and 6 inches in breadth; a fifth, lower down, was 6 inches long and 5 inches in width; the sixth, which was as large as a man's head, was situated on the right hip; the seventh, which was a small one, was situated below the right trochanter major; and the eighth, which is perhaps the largest on record, arose from the left hypochondrium, and hung down as low as the calf of the leg, being 2 feet long and 3 feet 1 inch in circumference, and weighed, when removed, 46 French pounds. In this country Sir Astley Cooper removed one that weighed 37 lbs. 10 ounces; and Mr. Liston one from the scrotum, which weighed 44½ lbs. The latter gentleman also mentions having removed one the size of an orange from under the tongue.

Sir Benjamin Brodie, so eminently distinguished in every branch of his profession, thus describes the intimate structure of the most common kind of these tumors. The fat resembles ordinary fat, except that it is rather of a more delicate, and of a looser texture, and of a lighter colour. It is composed of lobules with very thin membranes between them, and externally there is a thin membranous bag in which the whole mass is contained. "This bag has a very loose adhesion to the parts in which it is embedded, but the adeps which it encloses adheres pretty firmly to it." These tumors Sir B. Brodie has found to vary in some degree, according to the tissues in which they form, and instances the chronic mammary tumor as a probable variety. These tumors sometimes, though rarely, suppurate, and are seldom malignant in character. (*Med. Gazette*. Feb. 1844.)

*Of Atrophy.*—Some tissues undergo a spontaneous atrophy, as the umbilical vessels, the thymus gland, the sub-renal capsules, the right lobe of the liver, &c. These have their brief periods of existence and then wither away. In old age the lymphatic ganglia are no longer visible; the ovaries are reduced to a mere capsule; the parenchyma of the lungs is singularly rarified; the bones are of less density, and the brain lighter than in manhood. In disease, however, parts are sometimes greatly atrophied; thus a whole lung may be reduced to the size of the fist, one hemisphere of the brain may be greatly compressed and diminished, a kidney may disappear, the liver or the spleen be greatly reduced in size, and the walls of the heart so attenuated as readily to rupture. All parts of the body, therefore, are liable to be partially or generally atrophied. It is unnecessary to add, that such a loss of power must in all cases produce feebleness of action and disease. It is remarkable, that in health, if one set of muscles be greatly exercised, some other set is usually atrophied. Thus the muscles of the legs of dancers are generally powerfully developed, while those of the arms are soft and attenuated.

Such are the general laws of inflammation and of the non-malignant diseases of structure. It will now be necessary to give their causes, symptoms, and modes of treatment, as they occur in the different tissues and organs of the body, purposely omitting to describe these diseases, when occurring in the eye, or in the bones, as being by convention the more particular province of surgery, and also the diseases of the skin, as unintelligible to the general reader, without the assistance of a large and expensive series of plates.

### Of Inflammation of the Dura Mater, and of other simple Organic Diseases of its Structure.

*Remote Causes.*—The principal causes which produce inflammation of the dura mater are diseases of the cranial bones, occasioned by mechanical accidents or the syphilitic poison, also the pressure of hydatids, or of a cancerous or other tumor of the brain. Rheumatic inflammation, or an extension of simple inflammation of the internal ear, as in otitis, are other classes of causes. In apoplexy, also, when blood is effused between the bones of the cranium and the dura mater, it is with difficulty absorbed, and becomes sometimes the cause of inflammation of that membrane.

*Predisposing Causes.*—Inflammation of the dura mater is extremely rare at any period of life; but as this disease results more usually from mechanical injuries or

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from the syphilitic poison, the earlier periods of adult age are most liable to it.

*Pathology.*—The dura mater is subject to diffuse inflammation, perhaps to the serous, for water has once been found between this membrane and the cranium; and also to the adhesive, to the suppurative, and to the ulcerative inflammations, and these sometimes terminate in gangrene.

In diffuse inflammation of the dura mater the large vessels of this membrane are congested; but they are not so numerous as in most other tissues, and consequently the redness is not so general or so intense. In the acute forms of this inflammation the membrane readily separates from the bone; and, if rubbed between the fingers, the dura mater readily separates from the arachnoid; but in chronic inflammation these parts often adhere with great tenacity. This inflammation may terminate by resolution, or it may proceed, and lymph be effused. The adhesive inflammation is best seen in injuries of the head, when portions of the dura mater are often healed, or even reproduced to a considerable extent by this process.

Suppurative inflammation is still more common, and is a form of disease often seen in disease of the cranial bones. In other cases, also, when blood is effused between the cranium and dura mater, suppurative inflammation often ensues from irritation, caused by the effused fluid. The pus thus formed may make its way either externally or internally. In the former case a puffy tumor forms on the scalp, which, being divided, exposes a portion of the cranial bone, white and dry, and this, in favourable cases, exfoliates, and gives an exit to the pus. In the latter case the dura mater may ulcerate, and the pus be effused into the sac of the arachnoid. It is not uncommon, after severe injuries, for a portion of the dura mater to become gangrened.

Besides the chromatous inflammations which have been mentioned, the dura mater is occasionally the seat of achromatous inflammation. The formation of cartilaginous and bony deposits is an instance of this. These alterations are in general limited to a few points, seldom exceeding the size of a pea; but in other cases opposite layers shoot towards each other, of considerable length and size, converting the whole of the falciform process into bone.

The dura mater is also occasionally the seat of polypous tumors, pulpy to the touch, of a distinct fibrous structure, and which often acquire a considerable size, sometimes as big as a pullet's egg. These tumors are often pediculated, and resemble a mushroom, and by their pressure not only the bones and membranes are absorbed, but the brain may also be disorganized. Their seat is sometimes that portion of the dura mater which covers the petrous or other portion of the temporal bone; but more commonly they form under the superior portions of the cranium, which being absorbed they appear externally. These tumors have sometimes been seen ossified. Rostan mentions another tumor incident to the dura mater, and which he describes as an inextricable net-work of blood-vessels, or a true nævus, having an erectile disposition.

*Symptoms.*—The symptoms of acute inflammation of the dura mater are fever, pain in the head, great restlessness, and delirium. In some cases the other membranes of the brain become involved, and effusion takes place, causing coma or paralysis.

If the inflammation succeeds extravasation of blood, the symptoms are, first, those of compression, which partially or wholly disappear. Some time elapses before matter is formed, when fever and delirium succeed. If the patient recovers, the bones exfoliate, and the matter escapes. If, however, he falls, the fatal catastrophe is again preceded by coma, and symptoms generally of compression.

Ossification of the dura mater is sometimes unattended by any symptom. In Dr. Pemberton's case, however, it caused the severest form of tic-douloureux of the face. It has also given rise to epilepsy and to insanity. A case of this latter description occurred in a man who had been many times insane, and at last died of an abscess of the brain. On examination the falciform process of the dura mater was found ossified almost throughout its whole extent, while the arachnoid was as dense as the dura mater.

It is singular, says Rostan, that polypi, as long as they are contained within the cranium, seldom give rise to any symptom; and Louis, out of twenty cases that he quotes in his Memoir on this subject, says, that in two or three cases only was there any lesion of muscular motion, of the senses, or of the intellect. These tumors consequently can hardly be determined to exist until they make their way through the walls of the cranium. They are of variable size, and pulsate synchronously with the heart. This action may be stopped by compression, made either laterally or perpendicularly; but in the latter case the usual phenomena of cerebral compression, as loss of sense, convulsions, coma, or palsy, are brought on, but which disappear as soon as the finger is removed. In some instances the bone is rendered so thin by the process of absorption that, just prior to the eruption of the tumor, it gives a sound, when pressed upon, like the cracking of parchment.

*Diagnosis.*—When the cerebral symptoms are preceded by rheumatism, or are the result of the syphilitic poison, we may, without hesitation, affirm the seat of the disease to be the dura mater. When they arise from other causes, the other membranes are in general involved in the disease, and the symptoms are too complicated to allow of an accurate diagnosis.

*Prognosis.*—The prognosis in cases of syphilitic or of rheumatic affections of the dura mater is always favourable, however formidable the symptoms may appear. When the inflammation arises from mechanical causes, the brain having sustained an injury, the prognosis is in general less favourable.

*Treatment.*—The treatment of acute rheumatic inflammation, before effusion has taken place, is by bleeding and by mercury, so as to affect the mouth; and in cases of syphilis, by the iodida of potash. If matter forms, and the bone does not exfoliate, nothing but the happy temerity of the surgeon in trephining can in general save the patient.

The osseous depositions of the dura mater, unless capable of being removed by mercury or iodine, are at present beyond the powers of medicine. The treatment of the polypous formations is entirely surgical.

### Of Arachnitis.

*Remote Cause.*—Arachnitis is a disease which most commonly occurs from the action of a morbid poison; and indeed there are few agents of that class which do not act on the membranes of the brain. There are many instances, also, of persons suffering from arachnitis after exposure to the heat of the summer's sun, or to

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the "*coup de soleil.*" Intemperance, as well as great mental anxiety, is also a frequent cause of the chronic forms of the disease. Arachnitis is also especially connected with insanity, and with every structural disease of the brain; and to these causes must be added mechanical injuries.

*Predisposing Causes.*—Every age is liable to arachnitis. Children are often attacked by it whilst teething, under the form of hydrocephalus acutus, and also when labouring under scarlatina, measles, or other disease caused by a morbid poison. Adult age, as well as the middle periods of life, are still more liable to this affection, both from the greater exposure to the action of the typhoid and paludal poisons, to mechanical injuries, as well as to the greater intemperance and greater excitement incident to this age. In old people arachnitis is likewise common, more particularly from the ramollissement and other organic lesions of the brain, to which they are subjected. Both sexes perhaps suffer in nearly equal proportions from this affection.

*Pathology.*—The serous membranes of the brain are liable, with little exception, to all the forms of inflammation incident to serous membranes generally,—or to the diffuse, the serous, the adhesive, the suppurative, and the ulcerative; and these inflammations may be either acute or chronic.

In diffuse arachnitis the arachnoid has seldom any considerable redness or congestion, but is thickened and opaque; while the transparent serum naturally contained in the cavity of the arachnoid being now scanty, or wholly wanting, it has neither that polish nor that moisture which is natural to it in health, so that it appears brown and dry. The principal phenomena of arachnitis take place in the pia mater, so that the large vessels of that membrane are greatly congested; but still, according to Dr. Baillie, the redness is not so general or so continuous as in inflammation of other serous membranes. Also, if the pia mater be attempted to be removed, it is easily torn, and separates from the brain in small fragments. The arachnoid covering the dura mater seldom participates in this affection. These are the appearances observed in diffuse arachnitis, supposing it to terminate by resolution. The inflammation, however, often proceeds, and may now terminate by effusion of serum, lymph, or pus.

When serum is effused into the arachnoid cavity, the opacity of the arachnoid gives it a gelatiniform appearance; but when that membrane is divided it is found to be fluid, and to diffuse itself in every direction. Sometimes, however, the serum is found to be turbid, from an admixture of a small portion of free albumen. It is also not unusual to find a few points of lymph, of pus, or of blood, either at the exterior surface or in the cells of the arachnoid, effused along with the serum, and almost in juxtaposition with each other; so that every form of inflammation may co-exist at the same time in this membrane. The quantity of fluid effused is very variable, or from two to three drachms to as many ounces. The effusion most commonly takes place at the upper surface of the hemisphere, but sometimes at the base, and sometimes into the ventricles of the brain.

It is seldom that the inflammation is of greater intensity than has been mentioned, but occasionally it is so; and lymph is effused either into the *cavity* of the arachnoid, or into the arachnoid *sac*. Gendrin gives a case of a woman, aged 30, who, suddenly hearing of the death of her lover, lost her speech and her reason. After some months she so far recovered as to be sensible of her loss; but, although she shed no tears, she could speak of nothing else than their mutual affection. At length she relapsed and died; and, on opening the *sac*, it was impossible to distinguish the arachnoid, it being covered with a gelatiniform mass of loose lymph. Foville (*Art. Meningite*, p. 406, *Dict. de Médecine, &c.*) says he has met with six cases of this description, the effused lymph covering the whole of the brain, or nearly so, as far as the tentorium. The lymph was deposited in the arachnoid sac in two layers,—one adherent to the cranial arachnoid, and the other to the cerebral arachnoid; while between them was a stratum of serum, except in one case, where blood was effused. Foville mentions having had all these persons under his care for several years, and that they were all in a state of the dullest stupidity, and apparently labouring under paralysis of every sense. They were like statues, with this difference, that, placed upright, they preserved their balance; if pushed, they walked; and if food was placed in their mouths, they swallowed it.

When lymph is effused between the cranial and cerebral arachnoid, it is sometimes organized. Thus Rostan speaks of having found, in one of these cases, the cranial and cerebral arachnoids so thoroughly adherent as to form one mass, and Gendrin gives a similar instance of a woman of 70, who died comatose after a few days' illness.

Lymph also may be effused into the arachnoid cavity, but it is generally in small quantity, and is so seldom organized, that Louis states that he examined the brains of 200 bodies without finding a single instance. Rostan, however, is of opinion that in chronic inflammation of the cerebral arachnoid, the thickening is occasioned by the superposition of an organized false membrane, which, being detached, the original membrane recovers its primitive delicacy of texture, and almost its primitive transparency.

Suppurative inflammation may take place either into the arachnoid cavity or into the arachnoid sac. Rostan gives several cases of effusion of pus into the arachnoid cavity, and so does Morgagni, Cruveilhier, and Dr. Bright. Dr. Baillie states, he once saw pus effused into the cavity to such an amount as to cover the entire upper surface of the brain. Two cases are also given by Dr. Hodgkin of cut wounds of the head in which pus was found in the arachnoid sac.

The characters of chronic arachnitis are—a similar opacity and thickening of the membranes, together with granulations of a pearl colour, and more especially along the longitudinal sinus, and also an augmentation of the number of the glandulæ Pacchioni. Much serum is also effused into the cavity; and the cellular tissue by which the pia mater is attached to the brain acquires considerable strength, so that portions of the brain come away with the membranes. The surface of the brain is pale, and sometimes slightly atrophied. Ossification of the pia mater is extremely rare. Dr. Baillie, however, mentions one case, on the authority of Soëmmering; and Dr. Hodgkin speaks of a specimen in the museum of Guy's Hospital.

In acute arachnitis of the ventricles, the membrane becomes thickened, semi-transparent, pulpy, and sometimes sprinkled with minute spots of blood. It is rare to find lymph effused, but occasionally old adhesions are seen between the opposite surfaces of the ventricle. Pus has also been occasionally found in the ventricles, either

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as a primary disease, or else in consequence of suppuration into the cavity of the spinal arachnoid. The surface of the ventricles also has occasionally been found sprinkled with points of scabrous matter, like particles of pounded glass, or rather resembling the gritty matter found in the pineal gland.

From the abundance and size of the vessels of the plexus choroides, it might be supposed that this part would be greatly liable to inflammation; but its diseases are chiefly chronic and achromatous, as small cysts, which sometimes give to the plexus the appearance of a bunch of currants; they have also been seen as big as a gooseberry, and even as a pullet's egg. The plexus is also liable to the formation of white opaque points, which may attain the size of a barberry. These are sometimes soft, and sometimes of a firm consistency, and are liable to become loaded with earthy matter.

*Symptoms*.—Arachnitis is usually divided into three stages. The symptoms of the first stage are those of excitement, resulting from diffuse inflammation; those of the second are those of compression, marking that effusion has taken place; while those of the third stage denote recovery or death.

The first stage is ushered in by fever, at first remittent, but which at length becomes continued; the patient complains of headache, of light and sound being painful, while the conjunctiva is red and injected; yet with this increased sensibility he is torpid and unwilling to be roused. At the end of a short period he rambles or becomes delirious, and in some cases violently so: at length effusion takes place, and the second stage commences with symptoms of compression of the brain; the eye and ear are no longer painful; the delirium, from being active, has changed to low and muttering; the pupil dilated, and the supply of nervous fluid so irregular, that the muscles are affected with subsultus tendinum. The sphincters of the bladder are often contracted or relaxed, so that the urine flows incessantly, or else is retained altogether. The sphincters of the rectum are also often relaxed, and the stools come away without the patient's consciousness. The last stage is that in which these symptoms gradually subside, and the patient recovers, or else he becomes comatose, and dies in a typhoid state.

The duration of these stages is very various. Sometimes each lasts a week; and this, perhaps, is most commonly the case, but one or more stages may be wanting.

The tongue, in the first stage, is white; in the second, it becomes brown; in the third, it again cleans, or the patient dies. The pulse likewise in the first stage is from 90 to 100; in the second, from 110 to 130; and in the last stage it either gradually returns to its natural standard, or else runs on too rapid and too feeble to be counted.

The symptoms which have been described are those which mark arachnitis at the superior portions of the brain. When, however, it occurs at the base, or in the ventricles, some differences are observable; for the intellect is less impaired, but the passions more excited, and the patient lies fretful, impatient, morose, and, although somnolescent, he occasionally cries out, grinds his teeth, while the parallelism of the axis of the eyes is frequently affected.

Such is the more usual course of arachnitis, but Dr. Watson has given two cases of arachnitis in children, one 9 years, and the other 2 years old, in which a yellow adventitious membrane was spread out between the arachnoid and pia mater. In the first of these cases the attack came on suddenly in the middle of the night, the girl screaming from violent headache, and exclaiming somebody had given her a blow on the head. The other was equally suddenly attacked one morning with long and severe convulsions. They both appeared to have died comatose, the one on the sixth day, and the other on the fourth.

Chronic meningitis may exist *per se*, or may succeed to the acute form, and the symptoms of this affection are very various. One patient had no other symptom for some months than headache and paraplegia of the upper extremities, when he fell into a typhoid state and died. Often insanity is the first symptom; and this is followed first by the speech becoming affected, and then by hemiplegia, and this perhaps by apoplexy. The duration of this affection is from a few weeks to many months. The cases recorded by Foville of the statue-like character of the patients, when effusion of lymph has taken place into the arachnoid sac, are too few in number to allow us to consider the connexion between those symptoms and that peculiar form of disease as established; but should they ultimately prove so, it will be a curious problem to determine the probable cause of so complete an annihilation of the intellect.

*Diagnosis*.—Arachnitis is distinguished from encephalitis by the headache, the early delirium, and by the general absence of hemiplegia. It must be admitted, however, that disease of the brain, and of its membranes, is often conjoined, so that arachnitis is not in all cases a simple affection.

*Prognosis*.—Six cases of arachnitis out of seven are supposed to recover in fever. When it depends on mechanical injuries, the prognosis is more unfavourable; and should it become chronic, the ultimate result is often fatal.

*Treatment*.—The treatment of arachnitis, when arising from morbid poisons, will be mentioned under the head of the diseases caused by those agents. As a general principle, however, remedies have little influence over those forms of the disease. When arachnitis arises from mechanical injuries, the treatment is by bleeding, calomel, active purgatives, and by cold applications to the head. In chronic cases of insanity, Foville strongly recommends the cold *douche*, but with caution, as being a powerful depressant, yet producing less ultimate debility than bleeding. He seems to think it acts by cooling down the general mass of the blood, and producing a salutary general re-action. He quotes the experiment of Harvey, who, having passed a ligature round his arm, so as to stop the circulation, put the lower part of the limb into cold water; when that was sensibly cooled down, he removed the ligature, and speaks of having felt the cold blood flowing along the arm, &c., till it reached the heart, and gave the sensation of coldness in that organ.

The dietetic treatment should be strictly antiphlogistical, and the patient should likewise avoid all mental excitement; and indeed, if not secluded, should be kept tranquil not only in body but also in mind.

### OF ENCEPHALITIS, OR INFLAMMATION OF THE SUBSTANCE OF THE BRAIN, AND OF OTHER SIMPLE ORGANIC DISEASES OF ITS STRUCTURE.

Inflammation of the brain was a disease little known to the ancients, and even much still remains to be done in elucidation of this important subject. The writers who have most contributed to remove the difficulties con-



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nected with this interesting inquiry are Morgagni, Rostan, Lallemand, Bouillaud, and Abercrombie. 2368 cases are reported to have died of cephalitis in England and Wales in 1839.

*Remote Cause.*—Inflammation of the substance of the brain is caused by every morbid poison that produces fever. Many cases also result from mechanical injuries, others from the excitement of insanity and uncontrolled moral feelings. In some instances encephalitis has followed the suppression of a cutaneous eruption, in others caries of the bones of the cranium, and especially of the petrous portion of the temporal bone caused by otitis. Intemperance also is a frequent cause of this as well as of every other disease of the brain. As a secondary disease, encephalitis is produced by cancer, tubercle, and by every other structural disease incident to this organ.

*Predisposing Causes.*—Encephalitis occurs at every age: in childhood during the tendency to hydrocephalus; in adult age from the action of morbid poisons, and from mechanical and moral accidents; and in old age from the natural decay of the frame. If we assume ramollissement of the brain to be a form of encephalitis, that disease has occurred at the following ages, or in a few cases from birth to 15; thirty-nine cases occurred from 15 to 40; fifty-four cases from 40 to 65; and sixty cases from 65 to 87. The frequency of this disease, therefore, increases with age. Men are supposed to suffer in a larger proportion than women from this disease, and probably from their greater exposure to the exciting causes.

*Pathology.*—The inflammations of the substance of the brain have much that is peculiar. In a small number of instances they are chromatous, but in by far the greater number of cases they are *achromatous* or colourless. Taking both classes, the brain may be said to labour under the diffuse, the serous, the adhesive, the suppurative, and the gangrenous inflammations.

The red *diffuse* or chromatous inflammation of the substance of the brain appears to have many degrees. In the first degree the substance of the brain, when cut into, exhibits more bloody points than usual, so that the medullary substance appears as if sprinkled with blood, while the colour of the cortical substance is increased in intensity. If the inflammation assumes a higher degree, it only partially affects the brain, as one of the convolutions, or a small portion of a hemisphere; and the inflamed part now varies from a bright rose to a deep red colour. This increase of colour is supposed by many pathologists not to arise from any greater vascularity of the part, but from blood escaping from the vessels and becoming effused or infiltrated into the substance of the brain, forming, according to Boyer, so many apoplectic *foyers*. The inflamed part is generally swollen, and sometimes considerably so, and is generally softer, though sometimes firmer than usual.

The most common form, however, of inflammation is for the most part achromatous, and is termed *ramollissement* of the brain, and appears to be a variety of serous inflammation modified by peculiarity of texture. The characteristic of the part affected is, that it is generally whiter or greyer than the natural colour of the brain, and also softer than the natural substance of the brain. This softening has many degrees, and in its extreme form the brain is absolutely diffluent, so that it can be poured out of the cranium with as much facility as a thickened cream or a thin jelly can be poured from one cup into another. In this semi-liquid state much serum can often be expressed from it. This disease may be acute or chronic, and the following instances will show that its causes are those which produce inflammation in other parts of the body, and also that its course is similar.

Paroisse (*Opuscules de Chirurgie.* Paris, 1806) states that he examined the brain of twelve persons who died between the nineteenth and twenty-second days, after the loss of a considerable portion of the cranium from sabre wounds. Each wound was as large as the palm of the hand; and a considerable portion of the dura mater, as well as of the brain, had been cut off with the abscinded portion of the cranium. The most remarkable pathological phenomena in these cases was a great diminution in the size of the brain, and its extreme *softness*. There was no water in the ventricles, and the dura mater was dry. The arachnoid was strongly adherent to the brain, and in some instances appeared to have been partly destroyed by suppuration. In some cases there was little or no moisture in the substance of the brain, so that it appeared dried up.

Mr. Stanley gives two cases of hernia cerebri, in one of which, after excision of the protruded portion, "the protruded brain lost its natural colour, and acquired a light yellow appearance, was split into several portions, and often exhaled from it an exceedingly fœtid odour. Its substance daily became *softer*, ultimately acquiring an almost *semi-fluid* state, and in this state the whole mass wasted away. As the dead and putrid brain was detached fresh granulations rose to fill the vacancy, just as we see them arising from any surface from which a dead part has been separated by the natural processes."

In another case in which, after the excision of a portion of the brain, the brain again protruded, and acquired the size of a hen's egg. On examination after death, the protruded portion was in some parts *softened*, and had red particles of blood intermixed with it, while "all the medullary structure intervening between the base of the protruded part and the anterior corner of the lateral ventricle had entirely lost its natural structure, and had become *soft* and *pulpy*, so as to convey the idea of rottenness. Around this disorganized mass, and extending across the corpus callosum into the medullary substance, forming the roof of the opposite ventricle, the brain had undergone a change from its natural colour to a greyish-blue-white, while it still retained its natural consistency. It is remarkable that in this case during the last three days we noticed a very considerable quantity of fluid constantly oozing from the centre of the protrusion, whence it trickled down the cheek in a continued stream." Mr. Stanley conceives this fluid came from the lateral ventricles; although, from the soft and rotten state of the brain, he admits "we were not able to discover any distinct channel of communication between them."

In the cases that have been narrated, the injuries were most severe, and the termination fatal in a few days, so that no doubt can exist of the acute character of the ramollissement; and yet the pathological phenomenon in all was *softening*, without any red discoloration, thus rendering it highly probable, if not strictly demonstrating, that the softening must be the result of an achromatous inflammation. Another proof, also, of the inflammatory nature of ramollissement is afforded by Dr. Carswell, who states he has found the vessels of the part obliterated and indurated, traversing the diseased portion like so many small wires.

The forms of ramollissement may be chronic as well

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as acute, and these are also achromatous. It is singular how large a portion of the brain may be affected with this chronic disease, as a whole hemisphere, and sometimes the entire mass of the brain. The consistency of the diseased part varies, as in the acute form, from cream to a thin jelly, or probably according to the quantity of serum it contains. It is strange that when most diffluent it is still compatible with many of the functions of the mind.

Dr. Sims (*Med. and Chir. Trans.* vol. xix. p. 413) is of opinion that ramollissement is capable of being cured, and that the evidence of this fact is the disappearance of one or more layers of the cortical substance, as he supposes, by absorption, while the pia mater adheres to this part of the brain. The evidence of the cure of ramollissement in the grey matter of the corpora striata and other central parts, is the presence of a number of "holes," resembling, he says, Parmesan cheese, of a red colour, when there has been transudation from the blood-vessels, and of a fawn-colour in other cases. The part, he says, is also atrophied and softened; while the holes may be filled with a limpid fluid, sometimes lined with a membrane.

The next of the achromatous inflammations of the substance of the brain is that state in which, instead of being softened and diffluent, the brain becomes harder than natural, and acquires the consistency of white of egg boiled hard, or of well made *jaune mange.* M. Dance (*Répertoire Général d'Anatomie et de Physiologie*, 1828) gives the case of a patient who received a blow on the head about seven months before his death. He afterwards suffered from epistaxis, and severe and frequent paroxysms of headache. At length he fell down in walking from the bath, and died convulsed in about a quarter of an hour. On inspecting the brain the convolutions were flattened; there was very little blood, and no serous fluid in the encephalon; but all the substance of the brain resembled white of egg boiled hard. Its weight and density were considerable, and it yielded and recovered its form like an elastic body. There was no trace of a red vessel, so that the cortical substance was paler, and the medullary substance whiter, than usual. This may be considered as the result of adhesive inflammation; and that adhesive inflammation is a property of the brain is certain, from the formation of cysts, and of the union of divided parts by cicatrization.

The next form of inflammation is the suppurative; and the suppurative inflammation may be either acute or chronic. Most authors have supposed it may be of two kinds, or that the pus may be collected into an *abscess*, or else be *infiltrated* through the substance of the brain. This inflammation may perhaps be chromatous, but in the far greater number of cases it is achromatous, no trace of redness being seen in any part of the brain.

Abscess of the brain, then, is generally strictly achromatous, the surrounding substance of the brain being of the natural colour, except in a very few cases in which it succeeds to apoplectic effusion, when the walls of the cavities are dyed by the previously extravasated blood. Dr. Baillie says, when the abscess is of large size the weight of the pus breaks down the neighbouring parts, and they look simply as if they had been destroyed, or very much injured by the pressure; and also when the abscesses are small, there is an ulcerated appearance of the cavity in which the pus is contained. In other cases the usual membrane of an abscess forms. This membrane is at first extremely delicate, and easily torn; but as the disease advances it becomes of greater consistency, and even of considerable density, so that in some cases it is fibrous, fibro-cartilaginous, and even ossified, and is thus one of the causes of the formation of bony tumors of the brain. The patient seldom perhaps survives the formation of an abscess; but it is apprehended that the pus may be occasionally absorbed, and that the opposite walls may unite by granulations, and leave a cellular cicatrix. The size of the abscess is very various, being sometimes hardly bigger than a pin's head, and then again as large as a pullet's egg. When large they are seldom more in number than one; but when small there are sometimes several. The pus contained in them is often good laudable pus, but in other cases it is serous, and contains portions of lymph or albumen.

Infiltration of pus or purulent ramollissement is apprehended to exist when the brain is softened, and the diseased part of a yellow or cream colour. That this state of parts is owing to purulent effusion is a fact inferred rather than proved, and consequently this doctrine requires much further investigation before it can be considered as established.

Besides these forms of inflammation, Mr. Stanley has shown that in his cases of hernia of the brain, portions of the brain have *sloughed* away, have *granulated*, and have passed into a state of gangrene; showing that this organ, so singular in its structure, is possessed of every power of inflammation known to exist in other parts.

The pathology of the cerebellum, whether acute or chronic, is in every respect, as far as is at present known, similar to that of the brain.

It is impossible to give the relative frequency of these different forms of inflammation of the substance of the brain; but the red punctuated state of the brain is the most common, then the serous or ramollescent state, while all the other forms are infrequent. If we take ramollescence of the brain as the most striking instance of its disorganization, we find it does not affect all parts of the brain equally, for out of 171 cases there was,—

| | Cases. |
|---|---|
| Ramollissement of the whole of both hemispheres in | 4 |
| one hemisphere in its whole extent | 13 |
| single convolutions | 14 |
| convolutions and deeper-seated parts | 9 |
| anterior lobes | 27 |
| middle lobes | 37 |
| posterior lobes | 16 |
| corpora striata | 28 |
| thalami opticorum | 15 |
| walls of the ventricles | 2 |
| crus cerebri | 1 |
| various parts | 5 |
| | 171 |

The two hemispheres of the brain suffer from ramollissement with nearly equal frequency, or out of 169 cases the right hemisphere was affected in seventy-three cases, the left in sixty-three, and both in thirty-three instances.

Ramollissement of the cerebellum is much more rare than of the brain, and Andral states that, up to 1833, only thirteen cases of this affection had been recorded.



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In eight of these the disease was limited to one of the lateral lobes. In four, both lobes were affected; and in the last case there was an isolated ramollissement of the median lobe. In four of these cases the brain was concomitantly diseased, in another the mesocephale, and in another the spinal cord.

Encysted or other tumors have sometimes been found in the substance of the brain. Dr. Sims gives a remarkable case of this in a woman aged 48, who had hemiplegia of the left side for three years. In this case more than half of the substance of the right hemisphere was found to be wanting, and its place occupied by fluid contained in a membrane. The substance of the brain forming the walls of the cavity was fawn-coloured, and soft like jelly.* Hydatids are also sometimes found in the substance of the brain, and, according to Cruveilhier, the cysticercus is more common than the acephalocyst. Bony tumors are sometimes met with, and most commonly consist of an irregular mass, formed by bony processes, with a fleshy substance filling up the interstices; and of this sort of tumor, Dr. Baillie says there are several examples in Dr. Hunter's museum.

Otto, in his *Compendium of Pathological Anatomy*, translated by Mr. South, remarks that *hypertrophy* of the brain is especially produced in rickets, and in rare cases may occur even before birth; "that it frequently occurs at birth, when the brain sometimes attains a very large size. I have twice seen this to such an extent," he adds, "that the elasticity of the brain thrust up the calvaria at certain points, by bursting asunder slight sutures." Mr. Sweatman relates the case of premature development of the brain in a child 2 years old, in which this organ weighed 2 lb. $15\frac{1}{2}$ ounces avoirdupois, the average weight being, at this period of life, 2 lb. 1 to 2 ounces. Dr. Sims gives a case of a man whose brain weighed 3 lb. 9 ounces, the average weight being under 3 lb. In a girl 10 years old the brain weighed 3 lb. 12 ounces, the average weight being about 2 lb. 10 or 11 ounces. Otto thinks it may be a mode of cure of hydrocephalus, the ventricles having been expanded by fluid at some former period; while Andral thinks that repeated hyperæmia of the brain may be one cause among others of hypertrophy of the brain.

The brain is sometimes found *atrophied*. In a woman that died apoplectic, the brain weighed only 2 lb. 4 ounces, being $6\frac{3}{4}$ ounces less than the average weight of the brain at that age. The brain of a child two years old, that died of pneumonia, was weighed the same day, and was 2 lb. 3 ounces. Atrophy of the brain is for the most part a congenital disease; but it also appears to be a disease incident to old age; for the weight of the brain at 50 averages 2 lb. $14\frac{1}{4}\frac{3}{4}$ ounces, while at 70 and upwards it only averages 2 lb. $4\frac{8}{44}$ ounces.

The great physiological question connected with this portion of the subject is, whether the different parts of the brain, which have been observed to be the seat of the different lesions which have been mentioned, have demonstrated the phrenology of the present day, and shown the seats of the different faculties, either of mind or of motion. Andral has compared the different seats of lesion affected with ramollissement, but has found no constant connexion between the part affected and the mental disorder; and he thinks that the existence or absence of the disordered functions of the mind in cases of ramollissement depends much less on the seat of the alteration than on the sympathetic affection which exists between the softened part and the rest of the encephalon.

*Symptoms.*—Diffuse inflammation of the substance of the brain arises very generally, if not constantly, as a consequence or as a concomitant of arachnitis; and the symptoms are consequently identical,—as fever, headache, the senses pained by their natural stimulants, delirium, subsultus, coma, resolution of the sphincters, and death.

The symptoms of *Ramollissement* of the brain have probably a considerable latitude. In the twelve cases related by M. Paroisse, and resulting from wounds, he states that the symptoms were nearly the same in all, and were as follows:—The men all stated that after the wound they had felt no other inconvenience than local pain of the injured part, and that for two or three days afterwards they had all been able to march five or six leagues a day. On the third day, however, they had all been seized with fever, which terminated on the evening of the fourth day; but from that period they had suffered little, always preserved a good appetite, and prayed not to be put on a low diet. About the seventeenth day they became downcast and dejected, owing, probably, to many sloughs being detached, and much suppuration taking place about this time. On the following day they first lost the sense of smell, and then the senses of sight and taste. With these symptoms, but without fever or convulsions, they fell into an easy sleep; and, as if they had no further strength to contend with the disorder, they died between the nineteenth and twenty-second days from the infliction of the wound.

The symptoms which have been related by Paroisse agree entirely with those observed by John Hunter. That skilful surgeon observed that trifling wounds of the membranes of the brain were often followed by severe and extensive inflammation of those tissues, and by very dangerous symptoms; but if the injury had been great so as to have excised not only a portion of the arachnoid, but also of the substance of the brain, that the symptoms which followed were comparatively slight—a circumstance which he attributed to the brain in the latter case having room for expansion; and he therefore suggested the propriety of extensively lacerating the arachnoid and pia mater in all cases in which the dura mater alone had been wounded.

Idiopathic ramollissement may be acute or chronic, and its attack may be sudden, or preceded by some preliminary symptoms, as headache, or long-continued derangement of the digestive organs.

In whichever way the disease forms, the severity of its attacks are sometimes as formidable and as overwhelming as a fit of apoplexy. The patient falls down in a similar state of insensibility, and his limbs are similarly palsied. There is often no difference between apoplexy and ramollissement in the fit, but there are striking differences after recovery from the fit. On recovering from apoplexy, for example, the patient has some degree of intelligence; but after a severe attack of ramollissement, the mind is impaired and delirious. A woman, about fifty, had suffered from ill-health, but not by any headache, giddiness, or other cerebral symptom, when on a sudden she was seized as in apoplexy, and on recovering at the end of a few hours was hemiplegic, delirious, and did not know the persons about her. Bleeding and other antiphlogistic treatment appeared rather to aggravate the symptoms; and in a few days she experienced

* *Med. Chir.*, vol. xix.

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a second attack, after which she lay without speech or motion, and died in a typhoid state. In this case the left ventricle, on being opened, presented the appearance of an ulcerated surface, being very loose in texture, or in a state of ramollissement resembling curds and whey, except in some portions of it, which resembled a rotten apple.

In some instances the attack commences without the fit, but in almost as sudden a manner. A gentleman, whose health had been so good that he had dined out only a day or two before, found, on getting into bed, that his leg failed him. He rang the bell, but when the family reached the room, his mind was so far gone that he mistook the persons about him. As his head was evidently affected, some leeches were applied to his temples; but while they were drawing, his arm dropped, and in a few hours he fell into a typhoid state, with a brown tongue, so that it was necessary to support him with some glasses of claret daily. He at length recovered, and lived several years, but the hemiplegia remained.

In another case of a gentleman who had long suffered from derangement of the digestive organs, with a white tongue, and also with headache, the first symptom of the brain being structurally affected was, that on attempting to walk he found himself moving in a small circle around his room, and had no ability to walk straightforwards owing to a want of power in his right side. The paralytic symptoms increased, and in a remarkable manner, so that the pupil of one eye was dilated, and the other contracted: one side of the face was exceedingly sensible, while the other had lost all sensation. The right arm was palsied, while the left was numbed, and the left leg was palsied, while the right leg was benumbed. Every attempt to bleed this patient was followed by syncope, and he at last recovered by wine and tonics.

The cases that have been related are, perhaps, fair specimens of the acute attacks of ramollissement of the brain. In the chronic forms of the disease the course is slower, and Rostan divides it into two stages.

The first stage, preceded perhaps by headache, or by derangement of the digestive organs, commences by the patient complaining of vertigo, numbness, of a pricking of the arm or leg, and often of confused vision. In addition to these disordered perceptions, the judgment, the memory, or other faculty of the mind, is more or less affected, and the patient falls into a sort of senile *dementia*. His speech also is often affected, his answers slow and hesitating, and he has great disposition to sleep. In the midst of this overthrow of the functions of the brain, the functions of organic life present no remarkable alteration, except that in some cases the tongue is white, micturition difficult, the pulse slow, and the appetite voracious.

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The second stage is marked by decided palsy,—the use of a limb or of one side of the body being lost, sometimes suddenly and sometimes gradually. The speech is also more and more affected, so that the patient with difficulty makes himself understood. His tongue now becomes brown, his pulse rapid, and he lies in a typhoid comatose state, from which he rarely recovers. In some instances contraction of the limb occurs instead of relaxation, the extensors being palsied while the flexors still retain their full powers. Convulsions, also, of one or both sides of the body may take place in the course of the disease.

Palsy, it has been stated, not only affects the muscles, but impairs also the sensations of the limbs. Still in some cases the sensibility of the skin, instead of being lost or deadened, is singularly increased, so that the patient screams out if touched, or subjected to the slightest pressure; and this sensation of extreme pain, though frequently limited to one limb, yet sometimes extends over the whole body. Some patients compare it to the pricking of a thousand needles; others to the sensation of a burn, and which the slightest attempt to bend the limb renders insupportable.

The pulse is so little affected in chronic ramollissement of the brain, that in 97 cases out of 126 taken by Andral, he has not noticed its frequency; but it is occasionally something slower, and occasionally more frequent than in health.

The duration of life in ramollissement of the brain is very various, but in 109 cases the disease terminated in the following times,—

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | died in | 12 | hours | 7 | died in | 6 | days | 3 | died in | 15 | days | 1 | died in | 25 | days | 1 | died in | 65 | days |
| 1 | ,, | 15 | ,, | 8 | ,, | 7 | ,, | 1 | ,, | 16 | ,, | 1 | ,, | 29 | ,, | 1 | ,, | 68 | ,, |
| 1 | ,, | 24 | ,, | 8 | ,, | 8 | ,, | 2 | ,, | 17 | ,, | 4 | ,, | 30 | ,, | 1 | ,, | 190 | ,, |
| 1 | ,, | 32 | ,, | 3 | ,, | 9 | ,, | 4 | ,, | 18 | ,, | 1 | ,, | 35 | ,, | 1 | ,, | 220 | ,, |
| 5 | ,, | 2 | days | 5 | ,, | 10 | ,, | 5 | ,, | 20 | ,, | 1 | ,, | 36 | ,, | 1 | ,, | 5 | months |
| 9 | ,, | 3 | ,, | 4 | ,, | 11 | ,, | 3 | ,, | 21 | ,, | 1 | ,, | 47 | ,, | 2 | ,, | 6 | ,, |
| 5 | ,, | 4 | ,, | 2 | ,, | 12 | ,, | 1 | ,, | 22 | ,, | 1 | ,, | 49 | ,, | 1 | ,, | 1 | year |
| 4 | ,, | 5 | ,, | 3 | ,, | 13 | ,, | 1 | ,, | 23 | ,, | 1 | ,, | 60 | ,, | 2 | ,, | 3 | ,, |

The inference deducible from this table, is, that ramollissement of the brain is more frequently an acute than a chronic disease, the greatest number dying before the 12th day, while at the end of a month only 16 cases out of the 109 were living.

In the 13 cases which have been collected of ramollissement of the *cerebellum*, the lesions of intellect were trifling, while motion was greatly affected in all except one doubtful case, or in 10 there was palsy with or without contraction of the muscles of the opposite side of the body; in two others convulsive actions of both sides of the body, and in the last case which was observed by Rostan, the palsy was on the same side. In this case the disease depended on an exostosis of the petrous portion of the temporal bone. In no instance is any sexual desire recorded to have troubled the patient.

Induration of the brain is of rare occurrence, and its symptoms can hardly be said to be yet determined. In a case related by M. Dance,* the man received a blow on his head about seven months before his death; he afterwards suffered from epistaxis, and severe and frequent paroxysms of the headache. He fell down while walking from the bath, and died convulsed in about a quarter of an hour. Another case was that of a child,

* *Répertoire Général d'Anatomie et de Physiologie*, 1828.

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brought to St Bartholomew's Hospital in a state of insensibility, which lay for a week without motion or consciousness, and then died. The whole brain was as hard as the white of a boiled egg; but nothing could be learnt of the previous history. The brain of the celebrated Pascal was found to be indurated, and he died not only with hallucinations, but also labouring under a species of religious monomania.

The symptoms of abscess of the brain are likewise extremely obscure. In a case treated for disease of the nose, the man made no complaint of his head, and was able to sit up in bed, and to assist himself in every way, when he died suddenly in the night. To the surprise of everybody, an abscess of considerable size was found in the left hemisphere above the ventricle. In other cases, according to Dr. Baillie, pain, delirium, coma, and palsy are the symptoms observed.

The symptoms of hydatids of the brain are often very obscure. The slowness with which they form probably often causes the brain to become accustomed to their presence, and consequently they do not give rise to any very prominent symptom; Cruveilhier gives a plate of a hydatid occupying the internal surface of the right hemisphere, immediately above the corpus callosum, and which caused no cerebral symptoms. Dr. Baillie also gives a case in which a serous cyst, as large as a gooseberry, pressed on the optic nerves at their junction, and yet the pupils were not dilated, nor the eye-sight impaired till within a day or two of the patient's death. In other cases they cause severe headache, palsy, loss of sight, or of other sense, and also absorption of the bones of the cranium, coma, and death.

Atrophy of the brain is usually congenital, or the consequence of some severe hydrocephalic disease, and the parties suffering are generally idiotic, and possess but little use of their limbs. Andral gives a singular case in which the patient, a girl, though an idiot, was able to do little errands in the neighbouring villages, and lived to an early adult age, yet when examined after death was found to have no trace of cerebellum.

Hypertrophy of the brain is usually connected with hydrocephalus, or is probably caused by some inflammatory action. These persons seldom possess much power of intellect, but their faculties generally are less impaired than in cases of atrophy.

*Diagnosis.*—The great difficulty in the diagnosis of acute ramollissement is to distinguish it from apoplexy. The diagnostic symptom most marked, however, is the early delirium and hallucinations of the senses, occuring before the brain has time after the fit to become inflamed, a circumstance which does not ordinarily take place till four to ten days after the attack.

*Prognosis.*—The prognosis in every case of encephalitis is grave; but, as far as we can judge, even acute cases do recover, and live many years afterwards.

*Treatment.*—In diffuse inflammation of the brain arising from mechanical injuries, there can be no doubt that bleeding and the antiphlogistic treatment generally are most beneficial when employed with a wise discretion. When, however, the same inflammation depends on the action of a morbid poison, it is necessary to warn the inexperienced practitioner that such measures must be employed with the greatest caution, and in most cases are better omitted altogether; for we find in many cases of typhus fever, in which the brain is probably partially softened, that the patient recovers under a powerful stimulant treatment.

In idiopathic ramollissement of the brain, the treatment can hardly be said to be yet determined; but there is good reason to suppose that bleeding is injurious, and that most advantage is derived from the use of tonics, and of a nutritive diet. "If it was demonstrated," says Andral, "that ramollissement of the brain, was a form of inflammation, the therapeutic indications would be easy, for we should only have to apportion the antiphlogistic treatment to the strength of the patient; but so far from this treatment being successful, abundant depletion has been followed by a notable augmentation of the cerebral affection." Indeed every practitioner must often have observed, that when the brain has been softened, every attempt to relieve the patient by bleeding has not only entirely failed, but the fits of apoplexy have returned, or the hemiplegia has been increased. On the contrary, when the acute cases have been supported with wine, &c., these have sometimes recovered, though mutilated. Again, in the more chronic and fatal forms of the disease life is evidently prolonged by mild tonics, attention to the bowels, and by a liberal and nutritious diet. Beyond this the medical treatment of ramollissement of the brain is still a problem, with only a few unsure data to guide us for its solution. Little has been done to determine the treatment of induration, of suppuration, or of the other forms of cerebral disease that have been mentioned.

## Of Inflammation of the Membranes of the Spinal Cord.

*Remote Causes.*—The membranes of the cord, unlike those of the brain, are little acted upon by morbid poisons. The most frequent remote causes of inflammation of these tissues are, exposure to cold or wet, mechanical injuries, caries of the vertebræ, and perhaps diseases originating in the substance of the cord itself.

*Predisposing Causes.*—This class of disease is incident to every age, but is most common in childhood and in adult age.

*Pathology.*—The chromatous inflammations of the membranes of the cord are the same as those of the membranes of the brain,—or the diffuse, the serous, the adhesive, the suppurative, the ulcerative, and the gangrenous.

The rachidian dura mater may be inflamed either at its free or at its adherent surface. On examining the spinal canal, after tetanus or caries of the vertebræ, the cellular tissue uniting the dura mater to the walls of this cavity is often found greatly loaded with venous blood; and in some instances is broken down, so that the dura mater is entirely detached; which two circumstances being conjoined distinctly show this state of parts to be the result of inflammation, and not of congestion. This inflammation may terminate by resolution, or it may proceed, and serum be effused, as in two cases reported by Bergamaschi, in which he found that fluid poured out between the osseous structure and the dura mater. The adherent surface also is liable to the adhesive inflammation; for in the case of William Banks, who died in St. George's Hospital, on the 64th day after a fall from a scaffold 40 feet high, the fourth dorsal vertebra was not only found fractured, but there was a slight effusion of blood and *lymph* between the osseous part of the spinal canal and the dura mater. In another instance in which there was caries of the 8th, 9th, and 10th dorsal vertebræ, the adherent surface was not only

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injected and red, but contained a matter which appeared to be pus.

Besides the diffuse, the serous, the adhesive, and the suppurative inflammations, the dura mater appears liable to the ulcerative and to the gangrenous inflammations. In a case given by Ollivier,* of a druggist who died on the twentieth day after suffering from lumbar pains, with rigidity of the trunk and lower extremities, together with tetanic spasms, there was found, on cutting through the muscles of the lumbar region, half an ounce of pus, or more, which was traced to the cavity of the arachnoid, the rachidian dura mater having ulcerated and ruptured. The following case is an instance of gangrene of the dura mater of the cord:—A man, while carrying a heavy load on his back, fell, and fractured the ninth and tenth dorsal vertebræ. The operation of trephining the fractured parts was perfoemed by Mr. Tyrrel, in St. Thomas's Hospital. The man, however, died on the fifteenth day, and the portion of the dura mater which had been exposed by the operation was black, and similar to that of parts threatened with gangrene. In another case, also, a young woman, aged 27, was knocked down in the Rue Montmartre by an old woman falling upon her, out of a five-pair-of-stairs window in the delirium of fever, and had the fourth dorsal vertebra fractured. This patient lingered till the forty-ninth day, when, on opening the spinal canal, the dura mater at the injured part was found to be soft, easily torn, and black.

The dura mater of the rachidian canal is also liable to some achromatous inflammations. In a rachitic patient, 60 years old, only four feet high, and who had never been able to walk without crutches on account of a remarkable bandiness of his legs and thighs, there was found, besides other lesions, caries of the second cervical vertebra, and also several osseous depositions, as well as thickening of the dura mater, at the diseased part.

The spinal *arachnoid* and *pia mater* are liable to all the chromatous inflammations of the corresponding membranes of the brain, as the diffuse, the serous, the adhesive, the suppurative, and the ulcerative.

Diffuse inflammation of all the folds of the arachnoid has often been observed, those membranes being red and injected for a greater or less extent, till in some instances it has occupied nearly the whole length of the spinal canal; and it is probable, although the opportunities of examining the spinal cord are comparatively rare, that the membrane is not only red but dry.

Effusion of serum, both into the cavity and into the sac of the spinal arachnoid, is not uncommon. Lymph is more rarely effused, yet has occasionally been found organized, uniting the opposite sides of the sac together. The pia mater and the arachnoid have also been found adherent after effusion of lymph into the cavity; and instances have occurred in which all the layers of the spinal membranes have been found united to each other.

Suppurative inflammation of the spinal membranes also occasionally takes place. This form of inflammation, according to Ollivier, only occurs in the cavity of the arachnoid—" toujours l'exsudation puriforme est sous-jacente à l'arachnoide." This physician gives as an instance, the case of François Sabatier, aged 28, who, without any known cause, was seized with dorsal pains, lassitude, and weakness in all his limbs, and, as the disease advanced, with tetanic opisthotonos, which returned at irregular intervals. He died on the ninth day, and on examining the spinal canal the arachnoid *cavity* throughout its whole extent was filled with pus. The same author gives other similar cases, and finds that the suppurative inflammation usually co-exists with the adhesive inflammation.

Besides the chromatous inflammations the membranes of the cord are occasionally the seat of achromatous inflammation, whence result bony and cartilaginous formations. These deposits vary in size from a pin's head to patches of five or six lines in diameter, seldom exceeding in thickness a melon-seed; and this thickness, as in the melon-seed, diminishes from the centre to the circumference. They are sometimes exceedingly numerous, and sometimes cover nearly the whole extent of the membrane. Andral has met with them external to the dura mater, and as large as peas. Ollivier says they are formed on the rachidian arachnoid, while Dr. Sharpey and Dr. Hodgkin affirm they are formed between its layers.

*Symptoms.*—The symptoms of rachidian arachnitis are often obscure at the commencement, but the disease once formed, pains of the back, with affection of the muscles, and retention of urine, are the pathognomic signs of the disease.

A greater or less degree of pain of the back, proceeding from the point of greatest intensity of inflammation, is one of the most prominent symptoms. It may be limited to one vertebra, or may extend along the whole of the spine, and even down the thighs. Sometimes it is continued, sometimes intermittent, and in either case it may be of uniform intensity or else darting. Occasionally it is so severe as to cause the patient to shriek out. In one case the patient was so harassed that he could not lie down, but kept walking about the room in a state of extreme agitation, grasping the lower part of his back with his hands through the intensity of the pain; he had no interval of ease, and was sometimes incoherent and unmanageable. He died, and pus was found in the spinal arachnoid cavity.

The affection of the muscles varies from simple stiffness of the part to opisthotonos. This latter symptom is often limited to the neck or trunk, without the limbs participating, as in a case given by Rayer, in which the trunk and neck were drawn backwards, while the patient walked freely till the time of his death. In the case of a waggoner thrown off his cart and pitched on his neck and shoulders; the neck was stiff, the jaw was locked, the body convulsed, and the patient delirious. It was not till the twelfth day, however, that the lower extremities became affected and palsied, when the patient sunk into a typhoid state and died. A large quantity of pus was likewise found in the spinal arachnoid cavity in this case.

Neither the pulse nor the tongue are much affected at the commencement of this affection, but towards its close the one becomes rapid and feeble, and the other brown and dry, and the teeth fuliginous; the patient's state is now typhoid, and he dies delirious or comatose.

Retention of urine generally persists from the beginning to the termination of the disease. Constipation often exists to a great degree at first, but afterwards the bowels act regularly, or even suffer from diarrhœa.

The duration of this affection is very various; in acute spinal arachnitis life is seldom preserved beyond a fortnight or three weeks; but if the case be slight the pa-

* Vol. ii. p. 569.

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tient often recovers in six weeks or two months; while in chronic cases, if the disease be of a character to terminate unfavourably, the period may be much longer.

*Diagnosis.*—The symptoms which distinguish spinal arachnitis from inflammation of the substance of the cord are *pain* and *contraction* or *convulsions* of the limbs; for in pure myelitis there is seldom any severe or constant pain, while the limbs are generally palsied and their sensations benumbed or lost. It is distinguished from rheumatic lumbago or psoas abscess by the affection of the limbs and of the bladder.

*Prognosis.*—Many authorities consider spinal arachnitis to be incurable, but many cases marked by the characteristic symptoms in a mild form do recover.

*Treatment.*—Spinal arachnitis, seldom depending on a morbid poison, is perhaps, in all cases, best treated by bleeding and mild purgatives. General bleeding is sometimes necessary; but local bleeding, either by cupping or leeches, along the vertebral column, is most useful, and perhaps cannot be omitted with safety. The medical treatment consists in moderate purging by the neutral salts, as the sulphate of soda or the sulphate of magnesia; for as these act on the bladder as well as on the bowels, they are probably the best medicines. Whatever purgative, however, may be selected, it will be proper to continue it with the tinct. hyoscyami or other mild opiate, to procure the patient some relief from his sufferings. Mercury, it should be stated, is not supposed to exert that power in meningitis of the cord which it possesses over inflammation of serous membranes generally. The warm bath is an excellent adjuvant in the early stages of the disease; whilst in the latter stages blisters, setons, moxæ, or the ungentum antimonii tartarizati are more beneficial, or at least as a last resource are deserving a trial.

An abstinence from all animal diet should be imperiously prescribed throughout the whole course of the disease.

### Of Myelitis, or Inflammation of the Substance of the Spinal Cord.

*Remote Cause.*—The substance of the cord is acted upon by a very small number of poisons, and, consequently, the most common causes of disease of this portion of the nervous system are accidental violence, as blows or falls. Affections of the cord, however, sometimes occur idiopathically, and the constitutional causes producing it are exceedingly undetermined. Vogel considers them to be often owing to a suppression of the menses in the female, and to the suppression of a hæmorrhoidal flux in the male, while others attribute them to sitting in damp or wet clothes. Caries of the bones must also be an occasional cause.

*Predisposing Causes.*—No age, perhaps, is exempt from myelitis, but it occurs more frequently from ten years old and upwards. It is most common, however, in adult age, and more frequently attacks the male than the female sex.

*Pathology.*—As the spinal cord is a continuation of the brain, and similarly composed of medullary and cineritious matter, it is reasonable to expect its diseases will be similar, and such is the case. The chromatous inflammation of the cord is limited to the diffuse inflammation, which is characterized by a few more bloody points than usual, or else by a slight red or rose-colour suffusion. Dr. Budd mentions a case in which a man fell to the bottom of a barge, fracturing the third, fourth, and fifth cervical vertebræ. He died seven days after the accident, and there was found opposite the fourth cervical vertebra a portion of cord which felt soft, and on being divided it was found converted into a red semi-fluid pulp. The membranes were sound.

The most common affection, however, of the spinal cord is the *achromatous* ramollissement or serous inflammation. In this form of disease the substance of the cord is greatly broken down and softened, so as to be sometimes reduced to a mere pulp. Ollivier mentions a case in which it was so diffluent as to give the sensation of fluctuation under the finger. This disorganization sometimes embraces the whole thickness of the cord, sometimes only one of its columns, so that it is of very variable extent. It is constant, however, that the centre or *grey* substance of the cord is more softened than that of the circumference or white substance. The ramollissement may exist in the cervical, dorsal, or lumbar portions of the spine; but it is most common in the lumbar, and after that in the cervical portions, or in those parts which contain the greatest quantity of *grey* substance, and, consequently, the greatest number of blood-vessels. The part affected is generally swollen, a circumstance more striking than in similar diseases of the brain, because the spinal canal is large in proportion to its contents, compared with the cranium. The softened part is also generally ash-coloured or white.

Some pathologists have regarded ramollissement of the cord as a particular alteration of the nervous system, as resembling the effects of a contusion of soft parts, and the result of the shock. It often occurs, however, when no shock has been received, and has not the least resemblance to a contusion of soft parts; and as this singular state of parts is produced in the brain by morbid poisons, the admitted causes of inflammation, as well as accidents, there seems no hypothesis so satisfactory as that which attributes it to the result of an achromatous inflammation.

Induration of the spinal substance is another result of achromatous myelitis, and is probably a further stage of inflammation, corresponding to the adhesive inflammation. Portal states he has found the cord of a cartilaginous hardness, while the membranes were red and inflamed; and Abercrombie gives a similar case.

The substance of the cord may likewise fall into suppurative inflammation; and some authorities conceive that the pus may be infiltrated, as well as collected into an abscess. The fact of infiltration is perhaps questionable, but there can be no doubt of an abscess having occasionally formed in the substance of the cord. Velpeau,* indeed, gives a case in which an abscess was formed in the right column of the cervical portion of the cord, three inches long and two lines broad, while a smaller one existed also in the left column. This form of the disease is also void of colour, and is achromatous.

Gangrene of the cord has been seen, but is extremely rare.

In some cases the spinal cord has been observed hypertrophied, either in its whole extent or partially. In the former case it fills the whole cavity, and is exactly applied to the walls of the osseous canal. Laënnec has observed this hypertrophy in all the extent of the cord; Andral has seen it limited to the cervical region of an epileptic child, and Hutin has given a case

* *Revue Méd. Franç. et Etrang.*, vol. ii. p. 217.

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in which this hypertrophy existed from the occipital foramen to the middle of the dorsal region.

Atrophy of the cord is more rare than of the brain, but it sometimes exists, and it may be general or partial. Ollivier has twice seen this atrophy in all the extent of the cord. In one case it was reduced to one-half its usual size, and in the other it was one-third less. Magendie has seen a third case, in which the cord was not only diminished in size, but also indurated.

Of partial atrophy of the cord, M. Ollivier has seen a case in which the cord was so contracted at the last dorsal vertebra that it did not exceed three and a half lines from side to side, and little more than two lines from back to front. In another case of caries of the vertebræ, all the white substance had disappeared, and exposed the central grey substance. In another, the cord at the lumbar region was reduced to the size of a goose quill. Sometimes partial atrophy of the cord has been caused by the pressure of hydatids, or from a dislocation or other diseased state of the atlas or dentatus, or from a contracted occipital foramen.

Some few instances of ramollissement have been observed, limited to the anterior or posterior columns of the cord, but they have not supported Sir Charles Bell's doctrine of the former being the exclusive agents of motion, and the latter of sensation.

*Symptoms.*—The symptoms of myelitis are in general limited to the parts below the injury. In a few cases, however, the accidents are reflected from below upwards. In general both upper or both lower limbs are affected; but in a few instances only one limb. The first symptom is numbness, with a sensation of coldness down the limb. Shortly afterwards the patient complains of pain in the back, corresponding to the seat of greatest intensity of the inflammation; but this is not constant, for pain is often absent, even when we make pressure with the finger over the spinous processes of the affected part. These symptoms are succeeded by impaired motion, and often likewise of sensation of one or more limbs; and this is followed by paraplegia, or other form of palsy. The palsied limbs may be either relaxed or permanently contracted: thus the hand may be bent on the upper arm, or a leg be flexed upon the thigh; or the affected limb may be attacked with convulsive twitchings, or else may beat incessantly the devil's tattoo. As the disease advances the bladder becomes affected, and the patient is either incapable of retaining his urine, from the sphincters being palsied, or else it is suppressed from their permanent contraction. The action of the bowels is slow in the first instance; but towards the close of the disease the patient is often purged, and the stools pass involuntarily. If the disease be the result of an accident, the pulse is at first rapid and full; but if it be spontaneous the pulse is generally natural, until the powers of life are broken down by the continuance of the affection. As the scene draws towards its close, the nates and the prominent parts of the pelvic region, on which the body rests, ulcerate extensively, so that deep sloughs form, and although the patient, from anæsthesia, suffers no pain, he nevertheless ultimately sinks exhausted.

In injuries of the spine, from wounds and contusions, some differences in the symptoms have been observed, according to the seat of the injury. It is well known, for example, if the spinal cord be lacerated or divided above the origin of the phrenic nerves, or above the third cervical vertebra, death is the immediate consequence, the nervous influence being no longer transmitted to the diaphragm and other muscles of respiration. Petit gives two remarkable instances of this. The only son of a working man went into the shop of a neighbour, who, in play, raised the child from the ground by putting one hand under his chin, and the other at the back of his head. The child, only six or seven years old, struggled, dislocated his head, and died immediately. The father coming in at that instant, and transported with anger, threw a saddler's knife at the man, and lodged the cutting part in the back of his neck, and this man died within an hour. There are a few cases, however, in which disease of these parts has not been immediately fatal. Thus the odontoid process has been destroyed by caries, or the second cervical vertebra has been dislocated, and yet the patient has continued to live for some months, or even some years. A remarkable case of a diminished area of the occipital foramen, whence resulted great pressure on the cord, was met with by Mr. Holberton,* and yet the patient lived more than two years, the most remarkable symptom being an extremely low pulse. In these chronic cases the formation of the disease is slow, so that the cord becomes accustomed to the gradually increasing pressure, and the respiration consequently still continues to be carried on principally, though feebly, by the muscles of the neck and shoulders, the diaphragm and intercostal muscles being more or less palsied.

When the injury, however, is below the origin of the phrenic nerves, or at the level of the fifth and sixth cervical vertebræ, the inspiration is free, but the expiration is laborious, for the intercostal and abdominal muscles are paralyzed and incapable of assisting in that process. The patient can yawn, for that is an act accompanied by inspiration; but he cannot sneeze, for that is an act accompanied by expiration. At this point, also, the upper extremities are still palsied, both as relates to motion and to sensation. When the palsy of motion and of sensation is complete, the patient, says Sir Benjamin Brodie, during the short remaining period of his life, presents the extraordinary phenomenon of a living head, with its sensibility and muscular powers unimpaired, attached to a trunk and extremities of whose existence he is only conscious by the sense of sight. Another very common symptom connected with injuries of the upper portion of the cord is priapism. This affection shows itself about the second or third day after the accident, and generally subsides after the first fortnight. It sometimes occurs even when all sensation in the part itself is destroyed, so that the patient is not sensible even when the catheter is introduced.

If the injury be in the situation of the sixth and seventh cervical vertebræ, the palsy of motion and of sensation is frequently imperfect of the upper extremities, while it is complete in the trunk and lower extremities.

When the spinal cord has been injured in the part corresponding to the first dorsal vertebra, the upper extremities may still suffer from an incomplete palsy either of motion or of sensation, or both. When, however, the seat of the lesion is in a line with the second dorsal vertebra, the sensation and motion of the upper extremities remain unimpaired, but the respiration is still difficult from the palsy of the intercostal and abdominal muscles.

The symptoms, when the injury is in the lumbar

* *Med. Chir. Trans.* vol. xxiv. p. 180.



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region, are not dissimilar to that of the dorsal region, except that the respiration is unaffected. Dupuytren has remarked, also, when the lumbar region is the seat of the disease, that the sound introduced into the bladder is more frequently covered with incrustations, and that the patient also more commonly suffers from ulceration of the nates; but these symptoms perhaps result only in consequence of the patient surviving for a longer period than when the superior portions of the cord are affected.

In chronic affections of the cord the palsied limbs usually waste and become atrophied.

In cases in which a limb has suffered from palsy, both of sensation and of motion, some singular phenomena have been observed; or that when a stimulus has been applied to the palsied limb, it often occasions involuntary contraction of the muscles of that limb. Thus, when a feather is passed lightly over the hollow of the foot, as in tickling, convulsions occur in the limb although the patient is quite unconscious that anything is touching his foot. These movements also are quite independent of volition, and vary in extent and force inversely with the degree of voluntary power possessed by the affected limb, being most forcible when the loss of voluntary power is most complete, and diminishes gradually in extent and force as that power is increased. In some instances, by irritating one leg, movements were caused not only in that leg, but also in the other leg; and similar phenomena have been observed by Sir G. Blane and others, in decapitated animals, showing even a portion of the cord may furnish a supply of nervous energy after disease has interrupted its connexion with the brain.

*Diagnosis.*—Diseases of the spinal cord, and diseases of the brain, are often followed by nearly similar symptoms; and consequently the one seat may be confounded with the other. But the history of the case, or whether it has or has not been preceded by a fit of apoplexy or of epilepsy, will often enable us to determine the particular seat of the disorder. Myelitis is distinguished from lumbago, psoas abscess, and hip disease by the absence of pain, and by the existence of the palsy.

Another point of diagnosis is, can we determine from the symptoms whether the cord or the membranes be the seat of the disease? Baglivi and Pallisin trephined the spine in the dorsal regions of many dogs. These animals did not appear to suffer when the knife pierced the substance of the cord; but if the dura mater alone was pricked, they fell into convulsions. The same phenomena appear in many cases to follow in the human subject, namely, that when the cord alone is diseased, the patient suffers no pain; while on the contrary, when the membranes are diseased, he often suffers most severe pain, with convulsive motions of the limbs.

*Prognosis.*—It is certain that many cases of severe contusion of the spine do recover, although it seems probable some organic lesion must have taken place. There seems likewise no reason to doubt that as many perfectly recover from superficial inflammatory lesions of the brain after fever, so also that many slight inflammatory affections of the substance of the cord may subside, and the patient do well. Many cases, indeed, even when the bladder is slightly affected, do recover. If, however, the disease be of more than a few weeks' continuance the prognosis is always grave. Still some few do recover, the leg being withered. But more commonly the disease runs on, and the patient at length falls after a long struggle.

*Treatment.*—In classing ramollissement of the cord with inflammation, it might appear necessarily to infer that the treatment should be strictly antiphlogistical. It is questionable, however, whether this mode is at any time advantageous; and it may be laid down as a general rule, that bleeding ought not to be had recourse to after palsy has occurred. Previous to that symptom it may be admissible; but, even then, it sometimes happens that the symptoms are aggravated almost as soon as the blood flows. After the palsy has manifested itself, bleeding is plainly improper; for, the nervous influence being intercepted, the powers of the lower part of the body are so reduced that it readily runs into gangrene, a tendency which loss of blood greatly increases. "It is a great mistake," says Sir Benjamin Brodie, "to think blood-letting always proper." "I have no reason to think blood-letting arrests softening."

As bleeding rather aggravates than amends the symptoms, the greater number of chances of saving the patient rest no our acting on the alimentary canal so as to produce three or four motions in the 24 hours, and thus creating such a derivation as in some degree to relieve the parts: at least the greater number of patients that do recover are restored by these means. The purgative is not perhaps important; but as the neutral salts act not only on the intestines, but also on the bladder, that class of remedies is generally preferred. At the same time that the bowels are kept free, the patient should be allowed a liberal supply of wine, or from six to eight ounces daily, and should be indulged in animal food at least once a day. If these means fail, and the disease proceed, we have no specific remedy. Some physicians have recommended small doses of the tinct. of cantharides, but the result has been anything but satisfactory. Of the untried medicines perhaps the secale cornutum is of the greatest promise.

With respect to local applications, as blisters, moxas, or setons, they are possible remedies, but the tendency to gangrene renders their application of doubtful utility. When had recourse to, however, it would perhaps be better to apply them above the seat of the disease than immediately over it, the greater vitality of the superior parts giving us greater assurance of our being able to heal them.

### Of Inflammation and other Simple Organic Diseases of Structure of the Alimentary Canal.

The mouth, the great adit to the alimentary canal, is often inflamed. The mucous membrane of the tongue, the gums, and of the cheek and lips, is liable to inflammation and ulceration from a variety of causes, as sharp corners of the teeth, or rugged tartar on their external surfaces. These affections are seldom of much moment; and simple ulcers may be readily made to heal by abstracting the exciting causes, and the application of some astringent wash, or of some mild ointment. Ulceration of the mouth, also, when produced by mercury, even supposing the tongue to protrude, for the most part readily heals on leaving off the use of the medicine. In some few cases, however, the inflammation thus produced does not readily subside, and the salivation continues, the ulceration extends, portions of the jaw exfoliate, and in a few cases death results. In these severe cases it is necessary to support the patient by wine and sago, and by quina, or other tonic medicine, and also to wash the mouth frequently with an acid gargle, or with a solution of the chlorides.

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Elementary Principles of Medicine.

Besides these affections, the bones of the palate sometimes exfoliate, an affection most commonly the result of the syphilitic poison. The mucous membrane of the antrum maxillare is occasionally inflamed, when the symptoms are a violent throbbing pain in the part affected, in the temples, and in the teeth. The side of the face is likewise swelled from infiltration of all the soft parts, and the Schneiderian membrane of the corresponding nostril is generally red and swollen. If the disease terminates in suppuration, and no exit for the pus exists, enlargement of the cavity takes place, so that the ossa malæ project, or the orbit of the eye is thrust upwards. The mucous membrane also lining the antrum becomes thickened, when the small aperture by which the antrum and nostril communicate is closed, and no outlet left for the accumulating fluid. If the disease be not interfered with, the matter most usually makes its way by ulceration into the socket of a decayed tooth, or the anterior parietes is absorbed, and it now flows by the nose, by the side of the canine or small molar teeth, greatly annoying the patient by its fœtor and by the slowness with which the abscess is emptied. This affection, unless it is prevented forming by bleeding, fomentations, and by purging, falls in the latter stage entirely into the hands of the surgeon. There are likewise some other minor diseases of the mouth, as gum-boils, serous cysts, ranulæ, and the occlusion of the salivary ducts by calcareous deposits, but these also are surgical. The diseases of that part af the mouth termed the throat will be treated of under the head of the respiratory organs, as more intimately connected with the symptoms of disease of those parts. There are, however, two diseases of the mouth of sufficient importance to attract the attention of the physician, as the various forms of stomatis termed aphthæ.

### Of Aphthæ, or Inflammation of the Mucous Membrane of the Mouth. (*Thrush.*)

1019 cases are reported to have died of thrush in 1839, in England and Wales.

*Remote Cause.*—The remote causes of this affection are very various. It sometimes arises from mere derangement of the stomach and bowels, but more commonly from general debility; it is also the concomitant of the latter stages of almost every severe disease. Besides these causes, some peculiar states of the atmosphere appear to engender it, for it is epidemic in some years and hardly known in others. Thus Billard states, that out of 917 healthy children 228 were attacked in 1826; and, according to Valleix, out of 657 healthy children 140 were attacked in 1834, and 99 died. When epidemic, it appears to have a *contagious* property; for, according to Burns, a healthy child sucking the breast immediately after a diseased child, has taken the infection. M. Taupin says he has seen it communicated to a healthy child drinking out of the same glass, or eating with the same spoon, after an infected child. This physician also says, that at the Hôpital des Enfans it appears almost always as an epidemic.

*Predisposing Causes.*—This class of disease is extremely common in childhood, so that, according to Burns, every child has at some period or other an attack. In the adult, however, it is extremely rare as an idiopathic affection; but it is occasionally met with as a result of severe disease, as phthisis. Taking all the forms of this affection, M. Taupin says he has observed them in one case in twenty in children, and but only in one case out of 1900 sick adults. It is more frequent in boys than in girls. The most common age is while suckling, or during the two periods of dentition.

*Pathology.*—These inflammations of the mucous membrane of the mouth are of three kinds,—the characteristic of the first being an exudation of points of lymph of the size of a pin's head, or larger, over the surface generally of the mucous membrane of the cheeks, tongue, and gums; the second is marked by a thickening of the epithelium, with points of ulceration of that membrane, the base of the ulcer being the denuded tongue, &c., red and sore to the touch. These two forms of aphthæ are seldom idiopathic, but are most commonly only seen in the last flickerings of the lamp of life, and when the patient is wasted by long and chronic disease. The third variety is when the ulcer, though similarly situated, affects the deeper-seated tissues as well as the epithelium, and often occurs in children in the best health. This disease is termed the *thrush*, and we shall now limit our observations to this affection.

Aphthæ, or the *thrush*, consists of a number of small ulcers of the mucous membrane of the mouth, with edges either elevated or *à pic*, and with a greyish base. Authors have allotted to these a great number of different seats, as the epithelium, the mucous follicles, and the substance of the mucous membrane itself; but it is probable all these parts may be affected. They have also admitted two principal varieties of this affection, or aphthæ simplices, and aphthæ contagiosæ, the one being contagious, the other not so; but this difference of property is certainly not very clearly proved.

Aphthæ simplices are characterized by a number of little white transparent vesicles, which shortly rupture, leaving a small *round* white ulcer, surrounded by a reddish areola. The course of this disease is not determined, but it varies from a few days to two, three, or four weeks, and is supposed to be kept up by a succession of crops. This form of disease is found to exist in the pharynx, œsophagus, stomach, small and large intestines, and also about the anus.

The aphthæ contagiosæ differ little from the preceding, except that the ulcers are of an irregular oblong, and in size and shape about that of a barleycorn. They usually affect the edges of the tongue, the sides of the frænum, the outside of the gums, and the interior of the cheek; but in no instance has it been observed that these ulcers extend to the pharynx, or other part of the alimentary or respiratory canals. The course of these ulcers is not well determined; but sometimes they disappear in a week, while in other cases they will last for a month or six weeks; the same ulcers either continuing, or else being renewed by a succession of crops. This affection is usually accompanied by an abundant salivation, and sometimes by an enlargement of the glands of the neck. In this form of aphthæ, likewise, the poison appears to have an ultimate action on the parenchymatous substance of the lungs, terminating in a loose spongy hepatization.

*Symptoms.*—Some local pain and heat of the mouth, some difficulty in swallowing or suckling, with an alteration in the timbre of the voice; also some slight febrile re-action, causing the child to be fretful, are the principal symptoms marking aphthæ simplices.

The symptoms of thrush, or of aphthæ contagiosæ, are fever, which sometimes causes the child to be drowsy, oppressed, and hot for some hours to two or



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three days before the aphthæ appear. The ulceration established, the fever proceeds, often accompanied by much delirium and subsultus tendinum. The stomach and bowels also are much deranged, the stools green and acrid, so as to excoriate the rectum, and cause much pain. The pulse also is quick, and the tongue, though white at first, often becomes brown and dry; and these symptoms continue for two, three, or four weeks, when the child recovers, or else, perhaps, from some secondary action on the lungs, he ultimately sinks.

*Treatment.*—The treatment of aphthæ simplices depends on restoring the disordered bowels or other parts that may be diseased to their usual healthy actions; but it is necessary to add, that this treatment should be tonic, at least as far as the case admits of; and of tonics the infusi aurantii c. tinct. aurantii, are among the best for children. A small quantity of wine, mixed with three parts of water, may also be given once or twice a day.

The treatment of the aphthæ contagiosæ, or thrush, even when there is much fever and delirium, is also best treated on the tonic principle, and especially by small quantities of wine, together with attention to the bowels. Some practitioners add to this a local treatment of the borate of soda, mixed with honey, applied to the ulcers; others wash the mouth with infusion of roses, or else with a solution of zinc or other lotion; but these applications are not important. The treatment of the pneumonia, which sometimes follows this affection, is not determined. The little patient's diet should be slops, sago, arrow-root, broths, and light puddings.

Of Inflammation and of other Simple Diseases of Structure of the Mucous Membrane of the Œsophagus.

*Œsophagitis*—is an inflammation of the mucous membrane of the œsophagus.

*Remote Cause.*—Inflammation of the œsophagus is a rare disease, for the morbid poisons have little influence over this portion of the alimentary canal, and the general causes, as they are termed, as atmospheric vicissitudes, are in like manner seldom followed by inflammatory affections of this part. The most frequent causes of inflammation of the œsophagus are children accidentally drinking boiling water out of the spout of a tea-kettle; swallowing corrosive liquids, as the mineral acids; and wounds most commonly inflicted in the act of committing suicide.

*Predisposing Causes.*—Children a few days old are sometimes affected with slight inflammatory affections of the œsophagus; and such few other cases as do occur may probably take place at every period of life.

*Pathology.*—The mucous membrane of the œsophagus is liable to the diffuse, to the adhesive, to the ulcerative, and to the gangrenous inflammations; but no instance is known of its being the seat of serous or of suppurative inflammation, without breach of surface.

Diffuse inflammation of the mucous membrane of the œsophagus is characterized by a deep redness of the part affected, generally terminating by resolution, but occasionally followed by separation of the cuticle. If the disease proceeds, lymph is thrown out. In new-born children points of lymph are often found lying on the mucous membrane of the œsophagus, being apparently an extension of the thrush affecting the mouth and pharynx. Andral has once seen in a girl twelve years old lymph thrown out after the manner of broad bands in the pharynx, œsophagus, and stomach. After puberty this form of inflammation is still more rare, but there are some few instances. Cruveilhier says that he found among the preparations of Dupuytren a very remarkable example of inflammation of the œsophagus, terminating in the formation of a false membrane, which coated this canal throughout its whole length. Dr. Abercrombie also gives the case of a gentleman, aged twenty-six, who caught cold and died in about three weeks. The whole of the pharynx was covered by a loose adventitious membrane, which also extended over the epiglottis, and portions of it were found lying in small irregular masses within the larynx, at the upper part. A similar membrane was traced through the whole extent of the inner surface of the œsophagus, quite to the cardiac orifice.

Besides lymph being thrown out, the mucous membrane of the œsophagus may also ulcerate. Dr. Wilson, of the Middlesex Hospital, gives the case of a young woman, aged twenty-one, who had swallowed, as she supposed, about a table-spoonful of oil of vitriol. This patient survived forty-five weeks and three days. The œsophagus for the lower two-thirds was thickened and narrowed, and the seat of an irregular cicatrix, showing that an ulcer had existed and had healed.

These ulcers, in general, form on the anterior portion of the œsophagus, and by continued extension they at last penetrate the posterior surface of the larynx, so that the patient often dies suffocated from the escape of food into the lungs. Occasionally the ulceration takes place from without inwards. A lady took cold, as she imagined, by riding in her carriage with the window down. Much difficulty of swallowing ensued, and the probang could not be passed into the stomach. At the end of a few weeks she was seized with a sudden vomiting, and threw up a large quantity of matter, after which she rapidly recovered. There can be no doubt that an abscess had formed in the submucous tissue, which burst into the œsophagus. Mr. Travers has also given a case of a deep-seated tumor found on the right side of the trachea, which opened at length into the œsophagus, and the patient passed pus both by the mouth and anus. Wilmer has given the case of a patient who was wounded in the mouth by a small sword. An abscess formed, which opened internally into the œsophagus, and externally in the neck, and the pus which escaped was often mixed with alimentary matters. The part became *gangrened*—the carotid was laid bare—and the patient died.

*Dilatation.*—The œsophagus may be partially or generally dilated. Dr. Hanny (*Edin. Med. Surg. Jour.* vol. lx. p. 66,) gives a case of general dilatation in a young man aged thirty, who had suffered from dysphagia, and in whom the œsophagus was found dilated to the size of a child's arm, measuring six inches in circumference. The walls were thickened, but without ulceration or carcinomatous deposit. Instances of partial dilatation of the œsophagus are much more common, and very constantly exist when the cardiac orifice is obstructed, or the seat of cancerous deposit. In general there is only one pouch, capable perhaps of containing a large portion of an ordinary dinner; but in a few instances the dilatation is multiplex; and an instance of this is given by M. Roennow of a young person who suffered much from offensive breath, and in whom the œsophagus was found, after death, dilated into several cavities, containing the remains of aliment in a putrid state.

*Stricture* of the œsophagus is occasionally met with,

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and it may be partial or general. In cases of poisoning with the mineral acids, the whole œsophageal canal is found constricted and narrowed; the mucous membrane puckered up and contracted so as greatly to diminish the calibre of the canal generally. More commonly the stricture is partial; one circular muscular fibre perhaps having abnormally contracted, and in this state been bound down by adhesive inflammation, diminishing the diameter of the canal at that part to at least one-half. Dr. Baillie mentions a case in which from this cause the diameter of the œsophagus was so reduced as hardly to allow a garden pea to pass, yet in all other respects the œsophagus was healthy. The party had laboured for many years under a difficulty of swallowing, and could only pass substances of an extremely minute size into the stomach. A beautiful specimen of this description is to be found in the museum of St. Thomas's Hospital.

*Ramollissement.*—Guersent and Bouillaud have given several cases of rupture of the œsophagus in consequence of ramollissement. The following instance is related by Boerhaave. The Baron Wassonmaer, of an excellent constitution, but subject to the gout, had contracted the habit of taking an emetic after every excess at table, which with him was not infrequent. One evening, after a copious repast, his emetic not producing its usual effect, he made some efforts to assist it; all at once, however, he shrieked out, threw himself on the ground, and complained of atrocious pain, and of having felt something burst at the superior portion of his stomach. He died in eighteen hours. On opening the chest, the lung on the left side was found swimming in a fluid similar to that contained in the stomach. This fluid was traced to a transverse rupture of the œsophagus, without any trace of ulcer or erosion, and through which the fluid had made its way into the left cavity of the chest.

*Induration.*—Dr. Baillie is of opinion that induration of the œsophagus seldom or never exists, except as the first stage of cancer of this organ. Some writers, however, state that they have seen the œsophagus surrounded with a cartilaginous ring, and in one case that it was actually converted into bone.

*Polypi.*—Polypi of the œsophagus are much more rare than of the larynx. Graaëf, Schneider, Pringle, Monro, and others, have all, however, seen this disease.

Schneider says that at the autopsy of a woman, aged fifty-four, and who died of dysphagia, he found three polypous tumors in the œsophagus. These tumors were from an inch to an inch and a half long, and two of them adhered to the mucous membrane by a thin pedicle, while the third was attached by a broad base. In substance they were fleshy; except the pedicles, which were firm and white. The case given by Monro is one of great interest, as the tumor was made out during life, and successfully removed by a ligature. It is as follows:—

James Davison, aged 68 years, was admitted into the hospital for a polypus of the œsophagus. On examining the throat nothing extraordinary was discovered, but on irritating the pharynx till the man vomited, a long fleshy excrescence was thrown up, which filled the mouth and almost reached to the teeth. It had four heads growing from the same stem, and now so pressed upon the larynx that it could not be retained in the mouth longer than a minute without danger of suffocating the patient. For many years it had rendered deglutition difficult, respiration less free, speech less distinct, and produced frequent fits of coughing, by which it was forced upwards into the mouth. In a consultation, it was determined to remove it, first performing tracheotomy in order that the patient might breathe, and then by passing a ligature round the excrescence. This plan entirely succeeded, and a great part of the tumor separated and came away in the stools. Two years afterwards the patient returned to the hospital out of health and emaciated, not having been able for some months to take scarcely any solid or liquid food. He shortly after died, when the œsophagus was found to be distended by a large fleshy polypus, which grew from the anterior surface about three inches below the glottis, single at its base and divided into two heads, of which the largest and longest reached almost to the stomach.

*Symptoms.*—The symptoms of œsophagitis are almost entirely local, and consist principally of pain, of dysphagia, of the expectoration of a thick viscid mucus, and perhaps vomiting; emaciation follows the loss of nutrition, and the patient ultimately falls from inanition. Dilatation of the œsophagus is marked by nearly the same symptoms. Stricture of this canal may be determined by the introduction of a probang. In ramollissement of this part the patient, except perhaps suffering from indigestion, is generally in tolerable health till the rupture takes place, and then the aliment being effused into the cavity of the chest, he dies from pleuritis or asphyxia. The symptoms of induration without cancerous deposit are not determined. The existence of a polypous tumor can only be determined with certainty when it is high enough to be visible.

*Diagnosis.*—The diseases with which it may be confounded are similar states of the stomach; and the diagnosis in these cases is often difficult and perplexing. Stricture may be confounded with the spasmodic affections caused by an irritated state of the lung or trachea.

*Prognosis.*—Simple œsophagitis is probably often recovered from, as is seen after wounds of the throat partially dividing the œsophagus. The chronic forms of inflammation of the œsophagus probably often lay the foundation of the ultimate death of the patient. Ulceration extending into the thoracic cavity is in all cases fatal.

*Treatment.*—The treatment of œsophagitis is by small local bleedings, by warm cataplasms to the neck, and by moderately acting on the bowels. In the treatment of the more chronic forms some opiate is essential. The use of the probang must be left to the discretion of the practitioner; but it may be remarked, that there are few cases in which it can be really useful, for in dilatation and in stricture of this canal there is an equal danger of rupturing the canal and causing an ulcer. When the case is hopeless from the small quantity of aliment which reaches the stomach, life may yet be prolonged by enemata of broths, milk, egg wine, or other nutritious fluid matters.

### Of Gastritis.

*Gastritis*—is an inflammation of the mucous membrane of the stomach.

*Remote Cause.*—Gastritis is often the consequence of the action of morbid poisons, especially of the typhoid and paludal poisons, or of the poison of the hooping-cough. It is also very constantly the result of many other poisons, as arsenic, corrosive sublimate, or oxalic

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acid. This disease, however, is extremely rare from the action of general causes, for in the whole of the Peninsular war not more than six cases are reported among the troops, exposed as they were to every species of privation, and in civil life Louis opened 500 bodies without finding a single instance. Indeed, the difficulty of exciting acute inflammation in the stomach will be seen in the long escape of the polyphagist, who swallows knives and watches, and all sorts of heterogeneous things; and of the Indian, who passed many times daily a blunt sword into his stomach with impunity, till at last he pierced its coats and died. The stomach, also, we find, will bear tea or coffee of an almost boiling temperature, followed perhaps shortly afterwards by a quantity of ice. One of the persons resident at the Eddystone light-house at the time it was burnt, swallowed a quantity of molten lead when looking from below upwards to observe the progress of the fire. But even after this intensely hot substance had passed into his stomach, he lived several days. His attendants hardly believed his story possible, but on examining him after death a lump of lead weighing some ounces was taken from the stomach.

*Predisposing Causes.*—The few cases of simple gastritis that occur have been met with for the most part in adults.

*Pathology.*—The mucous membrane of the stomach is liable to the diffuse, the adhesive, and the ulcerative inflammations, and these may be either acute or chronic.

The pathognomic characters of acute red diffuse inflammation of the mucous membrane of the stomach are redness, increased thickness, and diminished cohesion, so that much larger portions of it can be removed by the handle of the scalpel than in health. The redness may consist of a few points, or it may be arborescent, or striated, or in patches of greater or less size, or it may occupy the whole surface of the stomach. The colour of the inflamed part is of a deep venous red, approaching to black; and if it be seen or represented of a lighter hue, this result has probably been produced by exposure to the air, which in a few seconds changes the venous tint into a bright scarlet. The seat of the redness is sometimes the villosities, sometimes the web of the membrane, and sometimes also the subjacent cellular tissue, which is often injected, and the seat of extensive ecchymosis. The parts most frequently inflamed are the cardiac or pyloric orifices, the fundus, the convexity of the folds, and sometimes the whole stomach. In chronic red diffuse inflammation there is the same deep venous colour, the same thickening, but the cohesion of the gastric mucous membrane to the subjacent tissue is increased. There is a great tendency also for the deep venous colour, as it subsides, to become changed to a rusty brown, or else to a slate colour.

The adhesive inflammation, or throwing out of lymph at the surface of the mucous membrane of the stomach, is a rare disease. Billard says he has met with it three times in the stomachs of children that have died of thrush; and Andral once saw it in the stomach of a child 12 years old. There is a specimen of this kind to be seen in the museum of St. Thomas's Hospital.

The mucous membrane of the stomach is often the seat of ulcerative inflammation. In some cases the ulcer is a mere erosion, but more commonly it has a distinct edge, generally sharp, as if cut by a punch, and again it may be depressed, shelving off into the muscular coat. In some few instances the edge is elevated and thickened. The *base* of the ulcer is the mucous, the muscular, or the serous coat; and in extreme cases the latter ruptures. It sometimes happens, however, that when the mucous membrane is ulcerated, the serous coat adheres to the surrounding parts, or to the walls of the abdomen; and in the latter case, if the ulceration proceeds, an artificial anus, as it is termed, may be formed, the food escaping externally; or it may adhere to the colon, and the food escape into that canal. Ulceration sometimes takes place from without inwards, as well as from within outwards; thus an abscess of the liver or spleen may burst into the stomach, and an ulcer of the colon has also been known to communicate with that viscus, the fæcal matter passing upwards. The *form* of the ulcer is very various, generally circular or oval, but sometimes linear, or irregular. The *number* is equally uncertain; generally one in chronic gastritis; but in acute gastritis there are often several, and in some cases the stomach is absolutely "*criblée*." In size they vary from a pin's-head to a sixpence, or to half-a-crown; and in some cases of poisoning from mineral acids, a large portion of the mucous membrane sloughs off. The ulceration in some rare cases has ended in gangrene.

*Hypertrophy* of the stomach sometimes extends to all its coats, or it may be limited to some one or more of them.

When the mucous membrane is hypertrophied it sometimes appears granulated; at others large patches rise up from half a line to two lines above the general level of the mucous membrane. Instead of affecting all the web of the mucous membrane, the villosities are sometimes alone hypertrophied. The muscular coat also often participates in the disease, and so also may the serous membrane; and when all the coats are affected the thickness of the stomach is often double or treble its usual substance.

*Atrophy.*—The membranes of the stomach may be collectively or individually atrophied. Atrophy of the mucous membrane may be limited to the villosities, which sometimes entirely disappear. Again, the mucous membrane may be generally atrophied till it is reduced to a third of its usual substance. The muscular tissue may be reduced to a few scattered pale-coloured fibres; while, taking the stomach generally, it may be so atrophied as to be almost without villosities, almost without muscular fibre, and so reduced as to consist only of an attenuated serous and an equally attenuated mucous membrane.

*Dilatation* of the stomach may be general or partial. Andral gives a case in which the stomach had acquired such an increase of size that it covered the whole mass of intestines, so that its greater curvature touched the os pubis. In stricture of the pylorus the stomach is often so dilated as to reach the umbilicus, and even often exists to this extent when the pylorus is healthy. This augmentation of capacity usually takes place at the expense of the muscular coat, of which only a few fibres can be traced, the great mass of them being replaced by an excess of cellular tissue. Dr. Baillie gives an instance of partial dilatation of the stomach, or of a pouch being formed in which five half-pence had been lodged. The coats of the stomach, he says, were thinner at this part, but were not inflamed or ulcerated.

*Contraction.*—The stomach is sometimes found so contracted throughout the whole of its extent as not to be larger than a portion of the small intestine. This state of parts is most common in drunkards.

*Ramollissement.*—We sometimes open patients and

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find that the slightest traction of the walls of the stomach ruptures them. In these cases the mucous membrane, the muscular coat, the peritoneum, and also the cellular tissue connecting these coats, are softened, and in some cases almost liquified, or transformed into a sort of transparent jelly, and has hence been termed, by Cruveilhier *ramollissement gélatiniforme*. This state may exist with the preservation of the normal colour of each tunic, or they may be paler or redder than usual. The ramollissement may be limited to one tunic, or extend to all. The splenic portion is the part most usually affected; but Andral has observed it over the whole of the surface of the stomach. In one instance the walls of the entire stomach resembled a cherry-red pulp; and the child died with continual vomiting. Another child had vomiting followed by convulsions and coma, and died in five or six days from the commencement of the illness. The stomach in this latter case was reduced to a fine web, and readily tore; but unlike the former case, it was remarkably white, although the course of the disease had been most rapid. In other cases the ramollissement is partial.

*Polypi* sometimes grow from the mucous membrane of the stomach. Breschet gives the case of a woman, aged 69, in whose stomach there was found a considerable growth of this description. M. Rullier presented to the Académie Royale de Médecine a stomach from which there grew no less than eighty of these excrescences, whose medium size was that of a hazel-nut. Monro gives the case of a lady, aged 45 years, and the mother of several children, in whom was detected, during life, a tumor as big as an orange, on the left side of the navel. Medicine afforded her no relief, and she died emaciated. On examining the body, the tumor was found to be adhering, by its neck, to the villous coat of the stomach. The surface of the tumor was smooth, and the body of it so firm, solid, and tough, that it was cut through with some difficulty. The section of the polypus exhibited an uniform surface. In the museum of St. Thomas's Hospital there is a stomach containing six or eight of these fleshy growths, each about the size of a small nut.

*Symptoms.*—Acute gastritis, with ulceration, is often seen in cases of fever, and often without any local symptom to mark it. In one case it was accompanied by great anxiety, restlessness, and depression, with great difficulty in swallowing, almost equal to that in hysteria; but there was neither vomiting nor pain, and many authors are of opinion that pain is rarely felt unless an eschar is detached and the subjacent tissues exposed.

Acute idiopathic gastritis is so rare that hardly any writer has ventured to describe the symptoms. When it occurs, however, from poisons, as arsenic, corrosive sublimate, or oxalic acid, the symptoms, though they greatly vary, are generally admitted to be pain of the epigastrium, increased on pressure, with vomiting and purging. The face is pale or red, and the eyes are faded or brilliant and injected, the skin hot or cold, dry or covered with sweat, and the pulse full and strong, or weak and rapid, according to the dose of the poison, and the stage of the disease, and the constitution of the patient.

The course of acute gastritis is generally short, and the patient usually perishes between the first day and the end of a week, and more commonly on the second, third, or fourth day. In cases more prolonged the patient appears recovered after the third or fourth day, suffers no pain, and the vomiting subsides; but this apparent convalescence is often interrupted at the end of two or three weeks by the detaching of the eschar, sometimes followed by hæmorrhage, and which compromises the life of the patient. In other instances the ulcer penetrates deeper, and the patient dies of peritonitis.

In chronic gastritis, even when ulceration exists, the symptoms present an endless series of shades. In general the patient experiences a dull pain in the epigastric region, considerably increased on pressure, and which is worse after eating. This pain sometimes intermits, but more usually is continued. The appetite may be diminished or increased; but digestion is generally difficult and painful, and sometimes followed by vomiting. The mouth is dry, the tongue red or coated, and the bowels irregular. One case is given, in which the suffering of the patient was so trifling that he was dining out, and in the act of singing a jovial song, when the peritoneal coat rupturing, he was instantly seized with most acute pain, and in a few hours died from peritonitis. Dr. Farr gives a case of a hairdresser in whom the pain occurred only at long intervals, and in severe paroxysms. This man had suffered occasionally from attacks of severe abdominal pain for seven years, but which were always relieved by a glass of brandy. On the day of the fatal attack he had endured the pain almost without interruption, yet continued to attend to his business, and in the evening even went to market to buy fish for his supper. On his return his suffering was intolerable. He took his usual glass of brandy; but this was followed by vomiting. He was anxious to get to bed, but dreaded going up stairs; at length, however, making a desperate effort, he ran up, and fell as he entered the room. Peritonitis was established, and after death an ulcer, with ruptured peritoneal coat, was found in the stomach. In chronic ulcer of the stomach the peritoneal membrane sometimes forms adhesions to the walls of the abdomen, and the ulcer eating through them, an artificial anus, is formed, which has led to many very valuable observations being made *per visum* on the nature of digestion.

*Hypertrophy* and *atrophy* of the coats of the stomach are perhaps not to be determined during life, except as matters of inference, from the indigestion which usually accompanies them. *Dilatation* of the stomach may perhaps be ascertained by examination, and this is especially to be suspected in the "huge feeder;" its enlargement being perhaps caused like enlargement of the bladder by over distention. It is also found in the melancholic patient. *Contraction* of the stomach is more usually seen in the drunkard, and is the consequence of over excitement from excessive stimulus. Louis states, that in the greater number of his cases of ramollissement the patient has laboured under indigestion, and often for years; but that at the period at which he conceives the ramollissement to have commenced, the loss of appetite was complete, and accompanied by gastralgia, nausea or vomiting, thirst, and some fever. These symptoms he considers to occur with or without exacerbations and remissions, till the death of the patient, which takes place in about six weeks or two months from the time the disease is well marked. Louis is also of opinion that, judging from the symptoms, persons affected with ramollissement do sometimes recover. It will be evident, however, that the symptoms which have been mentioned are common to many other disorders

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of the stomach, and can hardly be considered as sufficiently diagnostic.

We possess no means of determining the existence of polypi of the stomach, unless the tumor be so large that it can be felt through the abdominal parietes.

*Diagnosis.*—Gastritis, when accompanied with pain and vomiting, can hardly be confounded with any other disease. When those symptoms are absent, it may be inferred, from the character of the epidemic, but cannot be proved to exist. In general, however, in gastritis the whole alimentary canal is disordered, and the diagnosis between the parts primarily and secondarily affected is extremely difficult.

*Prognosis.*—A few patients recover from acute gastritis; still the numbers are but few. A few also do recover from chronic gastritis with ulceration. The celebrated Breschet, editor of Bichât's works, was satisfied he had an ulcer of the stomach, and recovered by observing a most rigid diet. He ultimately died of a different disease, and on examining his stomach a cicatrix was found marking the seat of the ulcer.

*Treatment.*—The mucous membrane of the stomach, like the mucous membranes generally, is little influenced by bleeding, however copious. Still in acute gastritis some blood should be taken, and twenty or such other number of leeches that may be thought necessary should be applied to the epigastrium, and the bleeding afterwards be encouraged by a large linseed poultice, applied to the same part. The rest of the treatment consists in the exhibition of effervescing draughts, calomel, or neutral purging salts, combined with opium or other narcotic, so as to relieve the distressing sickness, and produce some action on the bowels. In the chronic forms of gastritis bleeding is perhaps unnecessary; but the same medicinal treatment should be pursued, though with greater moderation; and as the patient recovers, some bitter or mineral tonic may be substituted for the opiate. The other forms of organic lesion are only to be cured by an entire abandonment of the causes which have produced them; and even then it must be doubtful whether the organ ever recovers its healthy state.

Both in acute and chronic gastritis, the party should be limited to light puddings or slops till the severity of the symptoms has passed, when fish, and then poultry, and afterwards animal food, may be progressively allowed.

### Of Enteritis.

*Enteritis*—is an inflammation of the mucous membrane of the small intestines.

*Remote Causes.*—The remote causes of enteritis are in many respects the same as those of gastritis, or the greater number of morbid or other poisons. The intestines, however, are much more frequently acted upon by those and every other cause than the stomach. The effects of wet and cold in disordering them are familiar to everybody. They are also more commonly deranged by errors in diet, as by acid fruits or pickles, which often agree with the stomach, but greatly disorder the intestines, and thus lay the foundation of inflammation. Enteritis is likewise produced by many mechanical accidents, as the many forms of hernia, from which the stomach is nearly free.

*Predisposing Causes.*—Age has much influence in the production of enteritis. The high susceptibility of the bowels in childhood greatly predisposes that period of life to enteritis. In adult age the greater exposure to morbid poisons, and to mechanical accidents, renders this form of disease likewise common to manhood. Old age, though far from being exempt, is not so liable to this affection.

*Pathology.*—Inflammation of the mucous membrane of the small intestines may take place either in the web of the membrane, or in the follicles, or both. The inflammations of the mucous membrane, taken generally, are the diffuse, the serous, the adhesive, the ulcerative, and the gangrenous, and perhaps all these different inflammations may exist in different parts of the same intestine at the same time. Suppurative inflammation, however, without breach of surface, is unknown in this part of the alimentary canal. The inflammations which have been mentioned may be acute or chronic.

Acute diffuse inflammation of the web of the mucous membrane of the intestinal canal is marked by the same pathological phenomena that we meet with in the stomach, or by redness, thickening, and impaired cohesion. The redness is the same as in gastritis, or a *deep venous red*, approaching to blackness; and this may be either partial or general, dotted or arborescent, striated or in patches. The thickening is generally sensible, and often considerable. The impaired cohesion is not so constant as in the stomach, and in no case can the mucous membrane be removed in such large portions. In the chronic forms of diffuse inflammation, the colour, thickening, and the cohesion, are not greatly dissimilar; but in general the thickness is more considerable, the cohesion of parts, instead of being impaired, is often rendered more tenacious, while the dark venous hue, on subsiding, leaves a greyish or slate-coloured tint, from a deposit of melanic matter in the substance of the membrane.

Serous inflammation of the mucous membrane of the small intestines may be inferred to exist from the large quantities of serous fluid often discharged by stool, during life, at the same time that the abdomen is the seat of pain and tenderness. After death the fact may be proved by the loose diffluent fæcal matter often found in the small intestine; at the same time the mucous membrane is partially or generally inflamed.

Adhesive inflammation of the mucous membrane of the small intestines is an extremely rare occurrence. "I have," says Dr. Baillie, "seen in violent inflammation scattered portions of coagulable lymph thrown out upon the surface of the villous membrane. This, however, is very uncommon" (p. 158). Billard has seen it but twice in the intestines of children. Andral has never seen it. A black man, a gentleman's servant, admitted some years ago into St. Bartholomew's Hospital, presented a striking instance of this disease. The man had been for some short time ill, when he was seized with dropsy, and for this disorder he was sent to the hospital. He died in two or three days, and, on opening him, the lower portion of the iliom for the space of eight or nine inches was covered with a false membrane, forming a perfect cylinder about two lines in thickness, but which did not present the slightest trace of organization.

Ulceration of the mucous membrane of the small intestines is much more common than adhesive inflammation, and is indeed by no means infrequent, especially from the action of the typhoid and the paludal poisons; and this ulceration may take place either at its free or at its adherent surface. When it takes place at the free surface the ulcer, says Andral, may form in the centre of a point of inflammation, the mucous mem-

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brane around being healthy, or it may form in the midst of an extended patch of diffuse inflammation without the follicular structure being in any degree affected. Again, the sub-mucous cellular tissue may inflame and become the seat of a number of small abscesses, which may point like so many pock. The apices of these abscesses become thinned and softened, till at length the mucous membrane ruptures, and the pus they contain is poured into the cavity of the intestine. The form, edge, and base of these ulcers are not unlike those found in the stomach, except that the ulcer with a sharp perpendicular edge, as if made by a punch, is much more rarely seen.

Besides *inflammation* and ulceration of the *web* of the membrane, the follicular structure may be either separately or conjointly with the former the seat of inflammation and of ulceration.

The follicular glands of the small intestines are liable to the serous, the adhesive, and the ulcerative inflammations. In serous inflammation the gland is enlarged, transparent, and looks like a drop of pellucid water, having a small black point in the centre, which is the mouth of the duct. When adhesively inflamed, the gland is smaller than in the former instance, opaque, and also much harder, so that they appear like a number of little white granules. The glandular structure also very readily runs into ulcerative inflammation, and when the *plaque de Peyer* is its seat the ulcer generally takes the oval form of the patch. These ulcers have various edges and bases, and sometimes burrow so deep as to rupture the intestine. As this form of disease, however, most principally occurs in typhos, dysentery, and as a consequence of phthisis, the reader is referred to those articles for the more general laws which attend this form of disease.

Inflammation of the intestines, says Dr. Baillie, sometimes, although rarely, advances to mortification. When this is the case the mortified part is of a dark livid colour, has lost its tenacity, and is very readily torn, or as easily as a rotten pear.

Ulceration and mortification sometimes lead to the perforation or rupture of the intestine, when, the contents of the bowel escaping into the cavity of the abdomen, the patient dies of peritonitis. The intestine, however, when ruptured, does not always give rise to peritonitis, for the ulcerated portion may adhere to some neighbouring viscus, as the kidney, liver, or colon; or it may adhere to the walls of the abdomen, and give rise to an artificial anus, so that the fæcal matter is discharged externally through an aperture of the abdomen. In a very few cases the ulceration, and especially when invagination has taken place, is so extensive that a portion of the intestine has been known to be detached and passed by stool. Hevin relates a case in which 28 inches of the small intestine were discharged by stool; and Andral another, in which 30 inches, together with a portion of the mesentery, was passed in the same manner, and yet this patient lived three months afterwards. The explanation of the patient being able to survive this extraordinary pathological result is twofold,—or, that the ends of the intestine, after the diseased portion has sloughed away, are so completely in contact as to unite by the process of adhesion; or else, as Mr. Travers has shown in his experiments on animals, that a layer of lymph is deposited around the peritoneal surface of the diseased portion of the gut, as around a broken bone, and this becoming organized about the time the separated portion is detached, the continuity of the canal remains uninterrupted.

The small intestine, like the stomach, may be *hypertrophied* on one or more of its coats, so that in some instances it has been found of double its natural weight and thickness. It has also been found exceedingly *atrophied*, even when in a state of chronic inflammation and ulceration, so that the membrane has become of extreme tenuity and almost semi-transparent.

Portions of the small intestine have also been found so enormously *dilated*, that Andral has seen the duodenum as large as the pyloric portion of the stomach; while, on the other hand, it is sometimes as remarkably *contracted*. Forten mentions a case of poisoning by nitric acid in which the whole mass of intestines might have been held in the palm of the hand. This contraction, however, may be partial, and be limited perhaps to a single muscular fibre, which has contracted under some high irritation, and become bound down by adhesive inflammation; and in this manner a *stricture* is formed. A young lady died of phthisis and of mesenteric disease, and, on examining her, a stricture was found in the upper portion of the ilium formed in this manner, which so contracted the diameter of the intestine at that part that it hardly exceeded that of a garden pea. A small plum-stone, which it was supposed she must have swallowed a twelvemonth before, was stopped at this point, being too large to pass through the stricture.

The small intestine, like the stomach, is liable to undergo the process of *ramollissement*, and is occasionally ruptured from this cause. A case of ramollissement of the duodenum was met with not long ago, when that intestine tore like a piece of wetted paper. In one instance a *fatty* tumor was found hanging pendulous by a thin pedicle in the small intestine. *Polypi* have also occasionally been found.

*Symptoms.*—Dr. Baillie says that inflammation of the mucous membrane, or enteritis, among other symptoms, is characterized by acute pain; and Dr. Good says that this pain sometimes "arises to agony." This, however, is erroneous; for the patient, as in fever, is often destroyed by enteritis without having complained of pain. Pain, however, sometimes does exist, or at least is made manifest by pressure; and in this case its more common seat is the ilio-cæcal valve, and the epigastrium, either because those parts are actually the seat of the disease, or else because those parts, like the extremities of a duct, are sympathetically affected. Another symptom in the great majority of cases is diarrhœa, often accompanied by meteorism, and in a very few instances by constipation. The functions of the stomach are in all cases impaired, and occasionally there is vomiting. These symptoms are generally combined with some fever, and a full but not very frequent pulse. The tongue also, if the disease be mild, is white and moist; but if severe, it is brown and dry, and the patient falls into a typhoid state. When the enteritis is the result of the action of a morbid poison, the fever precedes the other symptoms; when it results from any other cause, the febrile affection always succeeds. If the intestine be ruptured into the cavity of the abdomen, and peritonitis follows, the patient is seized with a sudden coldness, a most excruciating pain of the abdomen, and with a most rapid pulse, and in a few hours he lies in a state of irrecoverable collapse; and, except a short respite from pain after pus has been effused, he dies, and apparently from insufferable agony.



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The symptoms of chronic enteritis are nearly similar but more moderate,—that is, pain may or may not be present, and in no instance is it of great intensity; the bowels are generally relaxed and the stools sometimes mixed with blood; the patient has little appetite, or nauseates his food; the pulse is little accelerated; and the tongue white and coated, with often a bitter taste in the mouth.

Hypertrophy of the small intestines is not uncommon, especially in dropsy, when they sometimes acquire a double or triple thickness, and apparently an equal excess of weight. The intestines are also as constantly atrophied in phthisis, and their tissues rendered almost transparent; but no particular symptom has been remarked by which these different states can be determined during life; neither can dilatation of the intestine, except when it becomes the seat of meteorism. Stricture of the intestine is more strongly marked, as by frequent attacks of colic or constipation, or of diarrhœa; but even these symptoms, it will be seen, are not strictly diagnostic, as they are common to many other disorders of the intestines. The symptoms of *Ramollissement* of the intestine are extremely obscure, and are only determined to be derangement of the alimentary canal generally, as diarrhœa, indigestion, vomiting, and pains, often severe, but occurring in paroxysms,—symptoms which are common to many other diseases both of the intestines and stomach.

*Diagnosis.*—The absence of pain, so common in enteritis, renders it at all times difficult to distinguish that disorder from mere deranged function of the intestinal canal. Even in fever the existence of enteritis is often a matter of mere inference, deduced from the nature of the prevailing epidemic.

*Prognosis.*—Enteritis, when occasioned by fever, or by some mechanical cause, as hernia, is not always a grave disorder. Many, however, fall when it is caused by hernia. In fever, whether the follicular structure be or be not affected, one in six or seven are supposed to recover.

*Treatment.*—The treatment of enteritis, when not arising from a morbid poison, is by leeches to the abdomen, gentle purgative medicines combined with an opiate, fomentations, and purgative or opiated enemata. After the inflammation has subsided, mild tonics, as salicine, or the tinct. aurantii ex inf. aurantii comp., should be substituted, to recover the lost tone of the parts.

The diet of the patient should be strictly anti-phlogistical, or slops and light puddings.

### Colitis

Is an inflammation of the mucous membrane of the colon.

*Remote Cause.*—The colon, or large intestine, is acted upon by many morbid poisons, especially by the paludal poison. It is extremely sensible also to cold and wet; is readily deranged by every error in diet; and suffers indeed from all the causes producing inflammation in the superior portions of the alimentary canal.

*Predisposing Causes.*—Colitis is common to all ages. Children suffer from it during teething; the adult, after exposure in the paludal and typhoid poisons; and old age, perhaps, from the general predisposition there now exists to disease.

*Pathology.*—The inflammations of the mucous membrane of the colon are similar to those of the small intestines, with the addition, that it readily runs into the adhesive and into the suppurative inflammations. It so readily takes on adhesive inflammation, that large quantities of loose unorganized lymph are often passed, filling sometimes a large chamber-vessel. It also readily runs into suppurative inflammation, large quantities of pure pus being passed, sometimes many ounces, and indeed much more than can be accounted for by the ulcerated state of the intestine, and, consequently, it is highly probable this secretion often takes place without breach of surface. This intestine is also occasionally the seat of simple stricture, or it may be more generally contracted; more commonly, however, it is greatly dilated. It is also occasionally hypertrophied or atrophied, and is occasionally the seat of polypi.

*Symptoms.*—The *general* symptoms of colitis are not greatly dissimilar to those of enteritis; but the *local* symptoms are more marked, the stools being more frequent, often containing large quantities of mucus, lymph, blood, or pus. The colon, however, being an organ of waste rather than of nutrition, the course of this disease is often much longer than that of enteritis, and the patient preserves a much greater degree of *embonpoint*, and is less frequently affected with fever than in the latter disorder. The derangements of the stomach are also much less marked, so that he preserves some appetite. In other respects, however, the symptoms are nearly the same.

*Diagnosis.*—In colitis the stools are more frequent, contain more blood than in enteritis, while lymph or pus have hardly any other source than inflammation of the colon.

*Prognosis.*—The prognosis in all cases in which pus is not present is favourable.

*Treatment*—does not differ from that recommended in enteritis.

### Of Inflammation of the Liver.—Hepatitis.

Hepatitis is an inflammation of the substance of the liver, and is a disease which has been known from the earliest periods of medicine. The numbers said to have fallen from this affection in England and Wales, in 1839, were 428.

*Remote Cause.*—The remote causes of hepatitis are very various. The paludal poison is evidently its most frequent cause, and it is probably owing to this circumstance that hepatitis is so common in the East Indies; for in Bengal it forms six per cent., and in Madras 17 per cent.; or, taking the whole mortality of our armies in the East Indies, from this cause, it varies from six to 22 per cent. In this country, where hepatitis arises principally from general causes, and from errors in the quantity or quality of our diet, and more particularly from indulgence in spirits, only one person in about 145 is returned as dying of liver diseases. If, however, we include jaundice, which probably for the most part depends on chronic disease of the liver, and also the many cases of dropsy which often arise from diseased liver, the proportion will be infinitely increased, or perhaps not less than 1 in 8 or 10. The effects of general causes in the production of liver disease is remarkable in animals. Poultry, it is well known, are often "put up" with the intention of producing enlarged livers, and the means used are very various. A room of high temperature is essential, when some entirely deprive them of all food and drink; others of all drink, but cram them; while others feed them on charcoal. These methods not only cause fever and emaciation of the body generally, but also enlargement of the liver: which latter forms

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the dish, we can hardly call it the delicacy, known as the *pâtés aux grosses foies*. These conditions are nearly those in which the drunkard places himself; the spirits, a highly carbonized fluid, produces heat and fever, loss of appetite, and a thirst so great that ultimately nothing but spirits can quench it. The difference between temperance and intemperance in the production of hepatitis may be seen in the circumstance that 227 per 1000 of the European troops die from this affection in the East Indies, while the proportion among the native troops is only 70 per 1000.

*Predisposing Causes.*—All ages are liable to hepatitis. Children, if properly dieted, would, in all probability, be nearly exempted; but many of those of the lower orders are early initiated in the use of "a drop," causing a most fatal and unsightly enlargement of the liver. The middle periods of life, however, from a greater indulgence in this pernicious habit, appear most liable to this affection.

*Pathology.*—In treating of the inflammations of the liver, it is convenient to consider the inflammations first of the ducts and then of the substance of this organ.

The mucous membrane of the gall-bladder and ducts is liable to the diffuse, the adhesive, the suppurative, and the ulcerative inflammations. Thus, if a dog be purged with jalap, the mucous membrane of the gall-bladder is found red and injected; while, if the inflammation, from any cause, be more intense, it is not only red and injected, but also thickened so that a probe can hardly be passed through the swollen lips of the ductus communis or ductus cysticus. As instances of adhesive inflammation, Louis gives eight cases in which the ductus cysticus or ductus communis were obliterated and reduced to a mere fibrous cord; and every museum contains specimens of this kind.

Stahl gives a case in which the gall-bladder contained an ounce of pus unmixed with bile, and Andral has likewise seen pus in the gall-bladder. During the Walcheren expedition the gall-bladder was repeatedly found ulcerated, and Louis has given several other instances. The ulceration sometimes proceeds till the gall-bladder ruptures, and if the bile escapes into the peritoneal cavity the patient dies of peritonitis. Dr. Abercrombie has given a case of a man aged 50, in which the gall-bladder adhered to the walls of the abdomen and ulcerated externally, so that the bile continued to be discharged by this biliary fistula for three years, and sometimes so profusely that in a visit of 15 to 20 minutes, four ounces of bile have been collected. An instance is also given of rupture of the cystic duct at its entrance into the gall-bladder.

The gall-bladder and ducts, besides being inflamed, have often been found hypertrophied, and, in a few instances, atrophied; but they have been more commonly found dilated or contracted. When a calculus has just passed into the duodenum, the ductus communis has been found so enlarged as to admit the middle finger. Again, if that canal has been obstructed by a calculi or other cause, the gall-bladder has been found so enormously distended that, instead of an ounce of bile, its natural contents, it has contained no less than 12 pints.

The gall-bladder and ducts, besides being dilated, have not unfrequently been found greatly contracted. Mr. Twining says that in India the gall-bladder is commonly distended with bile in persons recently arrived in that country, and, as a consequence, inflammation takes place, which, on subsiding, is followed by a considerable contraction or diminution of its capacity. Andral gives a case of adhesion and ulceration outwards of the gall-bladder, and by which means biliary calculi were discharged externally through the walls of the abdomen; but on the party dying, not a trace of the gall-bladder could be found, and in its stead a mass of cellular tissue of considerable density, and in which the ductus cysticus terminated as in a *cul de sac*.

Besides the preceding forms of disease, the gall-bladder has been found *indurated*, and in some very rare instances cartilaginous and bony. Another disease incident to this cavity is hydatids. Simmons gives the case of a woman who had a tumor on the left side of the abdomen, and on examining her it was found to be caused by an immense gall-bladder, which contained 16 measured pints of hydatids. Walter also once met with hydatids in the gall-bladder.

Inflammation of the substance of the liver is not uncommon, and is limited to the diffuse, to the suppurative, and to the ulcerative inflammations. The liver is also known to possess the property of adhesive inflammation by its healing after being wounded; but, as no free lymph has ever been found effused into its tissues, this property, if called into play under ordinary circumstances, must be limited to mere interstitial deposits, causing enlargement or induration of this viscus. These inflammations may be acute or chronic, and the phenomena vary so much according as they occur in healthy or diseased livers, that Gendrin has produced inflammation of the livers of animals artificially in order to determine more particularly its effects in the healthy organ.

Diffuse inflammation of the liver is marked by the liver being greatly gorged with blood, by its being of an unusually deep venous or liver colour, by an evident increase of its size and density, while the finger more readily perforates it than usual. If we now cut into it, the ducts present fewer yellow points than usual, and on opening them we find them inflamed and gorged with bile less viscid than in health. In this state the capsule of the vena portarum, and also the duodenum, are red and injected; the mesenteric veins distended with blood, and the spleen evidently enlarged. If the diffuse inflammation be of a still higher intensity, the affected portion becomes marbled, and bile is no longer contained in the ducts, but in its stead a dark, turbid, bloody serum, while the substance of the liver is so broken down that the slightest pressure reduces it to a mere pulp like a softened spleen, and injections now neither penetrate the ducts, the arteries, nor the veins of the inflamed part. But even in this state the inflammation may terminate by resolution and the patient recover.

The inflammation, however, may proceed, and pus be effused, at first in the centre of the darkest and most disorganized spots, forming a number of different points or foyers which enlarge, unite, and at length form one or more abscesses. The abscess formed, a new process now commences, which is the formation of a lining membrane; but this is rarely perfected in consequence of the abscess rupturing, or of the death of the patient.

Inflammation of the substance of the liver for the most part produces inflammation of the serous membrane which covers it, by which means adhesions take place between the liver and the surrounding parts, and in this direction the abscess usually bursts. Andral has seen this accident take place into the pericardium.



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Not unfrequently it takes place into the stomach, duodenum, arch of the colon, or other part of the intestinal canal. It has been known to take place into the vena cava, the infundibulum of the kidney, and in one remarkable case adhesion took place to the diaphragm at a point where the lungs also were adherent, and the ulcer penetrated them, and the matter of the abscess of the liver was coughed up and spat out of the mouth. In other cases no adhesion takes place, and the abscess bursts into the cavity of the abdomen, and the patient dies of peritonitis. It is seldom that the abscess points in more than one direction; but there have been instances in which it has burst not only in one but in two and even three or more points.

The fluid contents of the abscess are in general well-digested pus. Sometimes it is sero-purulent, loaded with flakes of albumen or lymph, and sometimes merely an ill-conditioned sanies. The walls of the abscess are generally unequal, and have the appearance of an ulcer; and Mr. Marshall has in Ceylon seen them in a state of gangrene. It is seldom that more than one abscess exists, but occasionally two or more have been met with. The abscess greatly varies in size, sometimes being hardly bigger than a pea, while in other cases it has contained one, two, and even more pints of pus, so that the larger portion of the liver has been converted into a mere sac. Dr. Chisholm says he has witnessed three-fourths of the liver destroyed in this manner.

The form of abscess that has been described is of the acutest kind, and such as occurs in a perfectly healthy liver. But it sometimes happens that an abscess forms in a white or nutmeg liver, and in these cases scarcely a red vessel is to be seen in the whole substance of the liver, which is sometimes so soft that the blood-vessels have been dissected out by the finger. An abscess having burst, the patient often dies, but he also sometimes recovers. In the latter case the abscess granulates, and the part is repaired as in ordinary abscess; but, as in ordinary abscess, the granulations contract, so that a deep hollow with a central cicatrix marks the seat of this formidable affection.

Besides these acute forms, the liver is liable to many chronic forms of inflammation. It may, for example, be simply *hypertrophied*, acquiring a great size, thrusting up the diaphragm, and extending not only into the pelvis, but also far over to the left side. The increase of weight under these circumstances is often so considerable that the liver has been known to weigh between 30 and 40 lbs. Again, it may be simply atrophied and reduced to one-third of its usual size, or to a mere shapeless lump, and, in these cases, the fleshy fibre is often so changed as to resemble in some degree a muscular structure.

When the liver is hypertrophied or atrophied, it is often also indurated, or else softened. The hard indurated liver is well known, while, in some instances, it is so softened as to be almost a bag of blood.

The other varieties of chronic inflammation of the liver are very numerous; but there is one of them usually termed the "nutmeg," or granular liver, which requires some notice. To explain this form of disease, Andral supposes the liver to be composed of a fleshy substance, and of a cellular tissue, an hypertrophied state of the latter giving rise to the remarkable disease in question. Bouillaud has considered the liver to be composed of a yellow and of a red tissue, while Mr. Kiernan supposes that the difference of colour is the result of mere congestion, and conceives that the nutmeg liver is caused by thickening of the capsule of Glisson, which he has shown accompanies the portal vein, the hepatic arteries, and the biliary ducts, and forms a sheath around them. These hypotheses have been considered by Laënnec and others so unsatisfactory, that many pathologists have considered the peculiar appearance of the "nutmeg liver" to be owing to the deposition of a peculiar heterologue substance, which they have termed scirrhosis. It is evident much further observation is necessary to elucidate this subject; but one remarkable law in this affection is, that the liver is for the most part hypertrophied, and more especially the left lobe.

The substance of the liver is very often loaded or infiltrated with fatty matter, a degeneration termed steatoma, and which is common in phthisis. In this case it usually, but not necessarily, becomes larger than in health, often preserving the impression of the ribs, or of the finger. It is sometimes harder and sometimes softer than in health, is of a cream or pale yellow colour, sometimes resembling a dead leaf, with brownish or deep orange-coloured spots. The presence of fatty matter is determined by an unctuous feel of the liver, by its greasing the knife, and rendering paper smeared with it not only transparent, but also readily combustible, as if dipped in oil. It may also be obtained by boiling. Dr. Bostock compares it to tallow, and Mr. Bird to a soft brownish fat, very fusible, of an unpleasant odour. Vauquelin obtained from a liver of this description 45 parts of a yellow concrescible oil, 19 parts of parenchyma, and 36 parts of serosity. In some few instances, says Andral, the fat, instead of being infiltrated into the substance of the liver, is deposited in masses. This state of the liver, Mr. Bowman conceives, is caused by an unwonted number of granules of fat, of which in health each lobule contains only a few.

The liver is also often the seat of hydatids. These are for the most part contained in cysts, whose dimensions vary from the size of a nut to a large orange, occasionally occupying nearly the whole substance of the liver. The walls of these cysts are usually fibrous, and not to be separated from the liver without tearing that organ. It sometimes happens that the cyst is extremely superficial, and projects beyond the surface of the liver, so that should the disease be chronic, and the patient emaciated, the nature of the complaint can be determined during life. The hydatid cysts may at length rupture, and these animals escape either externally through the abdominal walls, or into the cavity of the peritoneum, or, should adhesions form, may even be thrown up by the mouth. In general, however, the patient falls before this latter addition to his miseries takes place.

*Symptoms.*—The symptoms of acute hepatitis, it might be supposed, were principally pain and tumefaction of the liver; but the liver is an organ of dull sensibilities, and its most acute and destructive inflammations often take place without any pain being present, certainly not severe pain, unless the peritoneal coat is affected. Thus, according to Mr. Twining, out of 28 cases admitted into the Calcutta Hospital, and which ultimately proved to be liver diseases, only 16 were determined at the time, five being considered to be dysentery, two continued, one intermittent fever, two abdominal inflammation, one chronic diarrhœa, and one debility.

The most prominent symptoms of hepatitis are, however, some tumefaction of the liver, some pain or uneasiness of the liver, or else of the adjoining parts, as the thorax, abdomen, or right shoulder; 2dly, an affec-

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tion of the bowels, as diarrhœa or dysentery; and lastly, pyrexia in a continued remittent or intermittent form.

When pain is present, it is found to be in most instances aggravated by lying on the right side, apparently from the greater weight now pressing on the liver, while, in a smaller number of instances, the pain is felt most acutely on turning on the left side, probably from adhesions having formed to the ribs. In general, however, the easiest position is on the back, or else a little over to the left side, and towards the termination of the disease the patient is sometimes observed lying in a position which he had previously declared himself unable to assume.

In a few instances acute hepatitis exists without any pyrexia. Some fever, however, is commonly present, and in general it often commences with shivering, vomiting, and purging—symptoms which gradually diminish in a day or two, leaving the patient comparatively free from fever, and the pulse nearly natural. These paroxysms, however, recur, and at intervals of various duration, sometimes returning as regularly as those of intermittent or of remittent fever, while, in other cases, the periods are less marked, the chief symptoms being rigors occurring at irregular intervals, frequent pulse and sweats, the latter chiefly occuring in the night, and so copious as in some instances to pour off the body of the patient.

The state of the tongue on the admission of the patient is usually furred and loaded, but in the course of a long disease it as usually cleans, or is only slightly foul, till the death of the patient. In some few instances, however, it becomes brown and dry.

The animal functions, as in phthisis, are often marked by the "cheerful hope" which illumines every hour the patient has to live, but in others the depression amounts to despondency, with restlessness and want of sleep. At last, however, delirium obliterates the past, and throws a veil over the future, and with this symptom the patient dies, either with or without jaundice.

In the midst of the symptoms that have been mentioned, perhaps the abscess points; and now the patient becomes hectic, his pulse rapid, and he is covered with a copious and clammy sweat. The life of the patient now in a great measure depends on the part where the abscess points; if it bursts for instance into the peritoneal cavity, the patient assuredly dies of peritonitis; while, if it bursts into the stomach or intestinal canal, or else externally, he often recovers. It is often necessary, when the abscess points externally, from the urgency of the symptoms, to open it; but Mr. Marshall found in Ceylon that in the majority of cases he examined the operation would have been fatal, no sufficient adhesions having taken place to fix the liver to the abdominal walls, and thus prevent the escape of pus into the peritoneal cavity. The abscess having been opened, the patient either sinks, or else re-action takes place; and when the fever thus excited abates, a laudable pus is secreted, the appetite improves, the abscess granulates and cicatrizes, the external wound heals, and the patient recovers.

The different forms of chronic hepatitis are hardly to be distinguished from each other, and are generally denoted by indigestion, irregularity of the bowels, jaundice, and dropsy. An indurated or hypertrophied liver can generally be detected through the integuments, and an examination of the right hypochondrium should never be neglected. Large hydatid cysts can also sometimes be determined during life either from the sensible fluctuation of the tumor, or from the irregularity of its surface.

*Diagnosis.*—Abscess of the liver is to be distinguished from enlarged gall-bladder or gall-ducts, and from encysted dropsy of the liver; diffuse inflammation of the liver from peritonitis. Chronic hepatitis is to be distinguished from leucorrhœal pains, from cancer, or other organic disease of the stomach.

*Prognosis.*—Acute hepatitis, occurring in a healthy liver, generally terminates favourably in this country. If, however, it occurs in an unhealthy liver, or as a sequel of dysentery, it is almost uniformly fatal. In the East Indies the mortality among the European troops is $34\frac{1}{10}$ of those attacked, while of the natives seized only one-tenth fall.

*Treatment.*—The treatment of hepatitis as it occurs in the East Indies, a disease from which two persons out of three alone recover, cannot be said to be efficient or even well understood, and consequently much difference of opinion must necessarily prevail on this subject, and much opposite experience. The two great experiments which have hitherto been made are bleeding and mercury; and it may be affirmed as a general result, that those means combined are more beneficial and are oftener followed by the recovery of the patient than either of them employed separately. In the young and sthenic European, then, in the East Indies, it is in general necessary to take 15 to 20 ounces of blood, and then to introduce mercury so as to affect the mouth, and as soon as that is accomplished the symptoms rapidly subside. One practical rule, however, is established with respect to the use of mercury in the treatment of hepatitis, which is, that after suppuration *has* taken place, mercury is not only inefficient but injurious. In Europeans, however, whose constitutions have been debilitated from a long residence in the East, bleeding is scarcely applicable, and mercury, from the more or less diseased state of the liver, ceases to produce its original good effects; still, however, it is the best remedy, but should be used with more caution, and many practitioners now limit themselves to pil. hydrarg. gr. v. two or three times a day, giving a draught containing some purgative salt every morning.

If suppuration should take place, the preceding treatment should be at once abandoned, and, if practicable, the abscess should be opened, for there is no chance of the pus being absorbed. As long a time, however, should be allowed to elapse as the patient's state will admit of in order that adhesion may take place. Still, on the slightest indication of the patient's sinking, a trocar should be introduced, for at such a crisis everything must be hazarded. The abscess having burst, either externally or internally, the patient must now be supported with a moderate quantity of wine, by a nutritious diet, and by mild tonics, as the tinct. aurantii, or the sp. ætheris nitrici. The time which elapses after opening an abscess till the patient's recovery is from one to two months.

In Europe, when the hepatitis depends on the action of a paludal poison, mercury so as to affect the mouth, as hydrargyri chloridi gr. v. ter die or bis die, is the most efficient remedy, and under it the patient for the most part recovers. When the hepatitis depends on any other cause, and occurs in a liver otherwise healthy, moderate bleeding is necessary; and the further treatment is a mild opiate, as the tinct. hyoscyami ℥ xv., with some mild neutral salt, as the sulphate of

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magnesia, or sulphate of soda, ℥ j. 6tis horis. It is remarkable that many cases of hepatitis occur in the foul wards of the London hospitals, while the patients are liberally using mercury; and Baron Larrey states, that in Egypt he has seen hepatitis occur in patients labouring under the influence of mercury. If acute hepatitis should occur in a liver previously diseased, perhaps some mercury is admissible, but such an accident in London is extremely rare, and the practice not determined.

In the treatment of simple hypertrophy of the liver, the most beneficial remedies are the neutral salts, combined with some opiate, preparation of iron, or mild tonic, as the case may require, mercury in these instances being generally injurious rather than beneficial. For the treatment of the nutmeg liver no efficient remedy has been discovered; but in this, as in some of the other forms of chronic hepatitis, mercury, in small doses, but persevered in so as to affect the mouth, often gives the patient great temporary relief, and removes the jaundice or dropsy with which it is accompanied. A combination, however, of mercury and some neutral salt is, in most cases, to be preferred. The old Indian is often benefited by a course of Cheltenham or Leamington waters, without mercury, showing the power which the neutral salts possess over this class of disease. No remedy is known for the fatty liver, nor do we appear to have the power of influencing the formation or stopping the course of hydatids.

### Splenitis

Is an inflammation of the substance of the spleen, a disease which is extremely rare in this country, only 27 cases being reported to have died in all England and Wales in 1838, and 29 cases only in 1839.

*Remote Cause.*—This disease is usually limited to certain districts in this country, as Cambridgeshire, Essex, or other paludal counties. It is common in the East Indies, especially in the low marshy districts of Bengal. It also occurs in the paludal districts of other parts of the world. Now and then it is said to originate from a blow or other accidental violence.

*Predisposing Causes.*—Splenitis is sometimes seen in children under 10 years of age, and is occasionally met with perhaps up to the age of 50.

*Pathology.*—The spleen is liable to the diffuse, to the suppurative, and to the ulcerative inflammations. It also possesses the property of adhesive inflammation, for wounds made into its substance have occasionally healed.

The few cases of disease of the spleen occurring in this country will account for its pathology having been little studied. In diffuse inflammation, however, of this viscus, we find it enlarged, of a deep venous colour, and its tissue so softened as to be readily broken down, or even reduced to little more than the consistency of coagulated blood. Diffuse inflammation may terminate by resolution, or it may proceed and pus be effused, and in this case one or more abscesses often containing several ounces of pus have been formed. The abscesses sometimes make their way to the surface, and thus demonstrate the ulcerative inflammation of this organ. Dr. Baillie mentions that the spleen has been found in a state of gangrene.

The spleen is sometimes hypertrophied. In the *Medical Commentaries* an hypertrophied spleen is mentioned which weighed 11 lbs. Portal speaks of another that weighed 30 lbs.; and Lieutaud met with one in a woman who had been ill 17 years, that weighed 32 lbs. It is singular that these large tumefied spleens sometimes subside very rapidly. Abercrombie mentions one that went down a week after the ague on which it depended had been arrested. The hypertrophied spleen is generally more or less indurated.

The spleen is occasionally atrophied so that little more than a rudimentary spleen remains. It is also found indurated and often greatly softened, so that it is imagined this viscus must be liable to the process of *ramollissement*, as well as of inflammation. Hydatids have been found in the spleen. In a few instances, small portions of the spleen, about the size of a nut, are found indurated and nearly white. These appearances are supposed to arise from slight effusions of blood into the substance of the spleen, which become organized, and the colouring particles being absorbed leave the appearances in question.

*Symptoms.*—Acute inflammation of the spleen is seldom seen unless accompanied by ague; and the additional symptoms are probably tumefaction and some pain of the left side, followed perhaps by dropsy.

In chronic affections even abscesses will sometimes form without any marked local symptoms. Dr. Abercrombie gives the case of a gentleman who was dyspeptic, but took a great deal of nourishment, who was much reduced in strength and flesh, but whose pulse was seldom more than 96 to 100; whose nights were good, though he was occasionally slightly feverish, and who was able till within a few days of his death to drive out in his carriage. This party at length died after suffering for two or three days from diarrhœa, but without any suspicion of the spleen being affected. On examination, however, the spleen was found something enlarged, and in its centre an abscess containing several ounces of pus.

The more common form of diseased spleen is hypertrophy; and in these cases it can almost always be detected by the touch, sometimes extending low down into the pelvic region, well over on the right side of the linea alba, and extending backwards almost to the spine. In these cases the patient complains of weight and uneasiness rather than of soreness; his pulse is natural, but his countenance is extremely sallow, his person greatly emaciated, his bowels irritable, and these symptoms are, for the most part, accompanied by œdema of the lower extremities, or by ascites. The most remarkable part of the history of these cases, however, is, that notwithstanding the sallow and emaciated state of the patient, he is often seized towards the close of the disease with hæmorrhage from the stomach and bowels, often so profuse that many pints have been passed or thrown up, greatly exhausting the patient, and rapidly hastening his dissolution. The cause of this cannot perhaps be well understood, but Mr. Hewson mentions as a curious fact, long known, that blood from the splenic vein does not coagulate, when exposed to the air, like the blood drawn from other veins. The large portion of the blood therefore circulating in these enlarged spleens, being thus rendered incoagulable, may perhaps afford some explanation of this unlooked-for phenomenon.

The course of chronic splenitis is generally long; the patient usually surviving one or more years in the worst cases.

*Diagnosis.*—Enlarged spleen can only be confounded with encephaloid or other tumor of the abdomen.

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Elementary Principles of Medicine.

*Prognosis.*—Patients affected with enlarged spleen, and immediately removed from the paludal district, probably recover in a large proportion. If, however, the disease becomes inveterate, the patient dropsical, and the peritoneum thickened, he may recover, but is seldom completely restored, and is liable to all the accidents incident to frequent relapses.

*Treatment.*—Bleeding in splenitis has not been found greatly to influence the disease, or to effect a cure, while mercury, so beneficial in similar states of the liver, has been found for the most part not only not to be useful but even to be most pernicious. "I feel," says Mr. Twining, "more anxious fairly to show the baneful effects of mercury in the disease now under consideration, because the instructions usually laid down in the best systems of medicine do not inculcate the avoidance of mercury in any case of enlarged spleen, nor do they advert to the pernicious effects of that state of disease which I have termed vascular engorgement." This gentleman, in further proof his position, gives 13 cases in which the patient either died of mortification of the cheek, the nose, the upper lip, or after having lost all his teeth, or a large portion of the jaw, in consequence of the use of mercury, or supposing him to have survived the employment of this medicine, the spleen remained permanently enlarged. Dr. Voigt also, physician to the Danish establishment at Serampore, says that, although most authors recommend mercury, it is an indisputable fact that a very small quantity, even a few grains, generally occasion a profuse salivation, and so violent an affection of the mouth that mortification sets in, the teeth drop out, the bones become carious, and death ensues. In India, consequently, mercury and bleeding are little used, and in their stead a *spleen mixture*, not very dissimilar to that recommended by Celsus, is most in vogue; and the best, according to Mr. Twining, consists of pulv. jalap, pulv. rhei, pulv. Calumba, pulv. zingib, potass. supertart. āā. ʒ j., ferri sulphat. ℈ fs., tinct. sennæ, ʒ fs., aquæ menthæ pip., ℥ ix. fs., of which an ounce or an ounce and a half is to be taken twice a day, or such quantity as may produce three or four stools in the 24 hours.

The spleen mixture is, in some instances, greatly efficacious, but in a much larger number of instances, it entirely fails; and under these circumstances the iodide of potassium and the bromide of potash have been recommended. Mr. Twining says he has given the tinct. of iodine in six cases of tumid spleen, and is satisfied it is of no use in that disease. Dr. Williams, however, in his *Elements of Medicine*, states, that in one instance, he has exhibited the iodide of potash in doses of gr. viij. ter die with most complete success. There are cases, therefore, to which it is applicable; but it must be admitted it more commonly fails. The same physician has given four cases of enlarged spleens in which the bromide of potassium was eminently beneficial, and restored the patient, curing his dropsy as well as the enlargement of the spleen. As no other remedy is at present even suggested for the cure of this intractable disease, the bromide of potash well deserves a further trial. The dose is gr. v. to x. ter die, out of camphor mixture.

### Nephritis

Is an inflammation of the kidneys. This disease, in an acute form, is extremely rare; for in the returns of the causes of death for England and Wales in 1838, only 157 cases, and in 1839, only 139 cases of nephritis are mentioned as having proved fatal in those years. Chronic affections of the kidney, however, are extremely common; and taking dropsy as very generally connected with diseased kidney, it is quite plain that the deaths from simple organic affections of these glands amount not only to an infinitely larger number than has been mentioned, but form a considerable portion of the general mortality.

*Remote Causes.*—The kidney is acted upon by some morbid poisons, as the small-pox, but they are few in number, and rarely produce extensive mischief. A great number of substances, however, as alcohol, cantharides, turpentine, rhubarb, neutral salts, &c., are carried to the kidneys, and consequently must produce abnormal action, and sometimes disease of these organs. There is likewise hardly any disorder incident to the human frame which does not modify the urine, and consequently affects the kidney. Every atmospheric change or alteration of temperature affects the secretion of the skin, and consequently of the kidney. Most moral affections also, as hysteria, grief, or other depressing feeling, produce a similar effect. Many local diseases likewise, as diseased states of the bladder, urethra, or the presence of calculi, are equally remote causes of nephritis.

*Predisposing Causes.*—Children, except they labour under calculi, are rarely subject to nephritis. These affections are consequently most commonly met with in the adult, and in these after the age of 30.

*Pathology.*—The substance of the kidney is liable to the diffuse, to the suppurative, and to the ulcerative inflammations.

The previously healthy kidney, when diffusely inflamed, is loaded with dark venous blood, is softer than natural, and is considerably enlarged. Externally its surface is dotted with a number of dark red points, often surrounded with a vascular net-work, while internally the cortical substance is more loaded than the medollary, and is also dotted with dark points, which Rayer supposes to be the Malpighian bodies injected. The mucous membrane of the pelvis of the kidney is also red and injected.

The diffuse inflammation may terminate by resolution, when it leaves the kidney probably harder than usual; but it may proceed, and suppuration take place, which, according to Rayer, is most frequent in the cortical substance. The pus effused may form one or more abscesses, which vary in size from a pin's head to a large cyst, formed by the entire destruction of the kidney. Rayer has given some drawings which he conceives to represent purulent infiltration of the substance of the kidney.

Besides the substance of the kidney being inflamed, the mucous membrane lining the pelvis and tubuli is also often the seat of the diffuse, the adhesive, the suppurative, and the ulcerative inflammations, and these inflammations have received the name of *pyelitis*, from πυελος, pelvis.

Diffuse inflammation of the mucous membrane of the kidneys is marked by redness more or less general, and of a deep venous colour of those tissues, and this redness is sometimes increased by small patches of ecchymosis. This inflammation may terminate by resolution, or it may proceed; and Rayer has given two plates in which lymph has been thrown out at its free

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surface. In other cases pus is secreted, and in acute pyelitis, says the same authority, we can sometimes determine the presence of pus, either by the eye or by the assistance of the microscope, in the urine contained within the pelvis. Ulceration is a possible condition of pyelitis, but is seldom met with in the acute forms of this affection.

In the chronic forms of diffuse inflammation of the mucous membrane of the pelvis, the appearances are for the most part similar to those of the acute forms, but the mucous membrane both of the pelvis and calices is more sensibly thickened, so that those canals are sometimes transformed into fibrous cords. If pus be effused and retained, the calices and pelvis often become enormously dilated, while the substance of the kidney is atrophied. Rayer has given instances of chronic abscesses of the kidney so large, that they have communicated with the liver, or ruptured into the duodenum, or have adhered to the diaphragm, and burst into the bronchi. He has also seen them extending downwards to the cæcum, or even to the crural arch; likewise opening in the back, and discharging urine and pus through a lumbar fistula, and these latter are instances of ulceration of the substance of the kidneys.

It will be seen also, from the above instances, that the mucous membrane of the kidneys is liable to ulceration, especially if the kidney be the seat of a calculus; and that these ulcers sometimes heal, is manifest from our occasionally meeting with cicatrices.

Rayer mentions having seen in acute as well as in chronic pyelitis the pelvic membrane covered with an eruption of transparent vesicles, like sudamina. Andral has likewise seen a vegetation, red and soft, with a broad base, of the size of a small nut, growing from the same tissue.

On examining persons who have died of pyelitis, or extensive abscess of the kidney, we often find sand, gravel, or a calculus, which has laid the foundation of the disease, contained either in the pelvis or calices. When calculi form, they are sometimes small, sometimes of great size, and sometimes composed of many small ones agglomerated together. Their form is extremely irregular, generally taking that of the dilated pelvis and calices in which they are retained, and from this cause are often knobbled, or branch out like a piece of ginger.

The kidneys are sometimes notably *hypertrophied*, still retaining their form, structure, and appearance. This hypertrophy may take place in one or both kidneys, and in every case in which one kidney is either atrophied or wanting, the remaining one is as a general law hypertrophied, and has often weighed eight or nine ounces, or more than two healthy kidneys. Hypertrophy of the kidneys often accompanies diabetes.

The kidneys are likewise sometimes *atrophied*; and this affection may be general, or limited to the cortical or to the medullary substance. Bartholin has seen them no bigger than a chestnut. Morgagni has likewise mentioned several cases of atrophy of the kidneys, and in one the kidney had scarcely the size of the surrenal capsule; and Rayer mentions a case in which the right kidney had not one-eighth part of its ordinary volume, although the calibre of its renal artery was nearly equal to that of the left kidney, which was of the ordinary size. The most remarkable partial atrophy of the kidney is the disappearance of large portions of its tubular structure, so that in some instances hardly a trace of it is left, a circumstance extremely frequent.

The pelvis and calices of the kidney are sometimes greatly dilated, without the slightest trace of inflammation. This state of the kidney is usually caused when an obstacle occurs to the passage of the urine, either in the urethra, bladder, or at the mouth of the pelvis itself. This state has been termed dropsy of the kidney or hydro-renal distension. At first the distension is trifling, but if it proceeds, a pyriform tumor forms in the fissure of the kidney, whose apex is downwards. Rayer has given a plate of one of monstrous dimensions; and Tulpius speaks of having seen one as big as the urinary bladder; Frank of one that filled the abdomen, and weighed 60 lbs. In Rayer's case, the kidneys were so compressed as to be no larger than a haricot bean.

Besides dropsy of the kidney, *serous cysts* very often form in the substance of the kidney. These cysts are almost always filled with a serous fluid, which, analyzed, gives albumen and the usual salts of the blood. These most commonly form in the cortical substance, are lined with a serous membrane, and vary in number from one to three or four, or even a greater number. In size also they vary from a pea to a goose's egg. These cysts also sometimes form in the surrounding cellular tissue, and sometimes with great rapidity. Mr. Cæsar Hawkins gives the case of a child run over at the end of September, and, on the 1st of December, a cyst had formed, which was punctured through the abdominal muscles, when 18 ounces of fluid were drawn off. The cyst filled again, and the child died on the 25th of December.

In a few instances cyst is contained within cyst; but this form is generally supposed to denote the presence of *hydatids* in the kidney.

The most frequent as well as the most remarkable of the diseases of the kidney, is that which is termed the *granular* or *Bright's kidney*. The disease known under this name has many varieties, and these varieties have been considered by some authors as so many distinct diseases, while others esteem them to be only so many different stages of the same disease. These Dr. Bright divides into three, Martin Solon into five, and Rayer into no fewer than six stages.

Those who contend for this difference of stages affirm that, in the first stage the kidneys are unusually large, flabby, loaded with dark venous blood, and hardly in any respect differ from what is observed in diffuse inflammation, except that externally the kidney has a granular appearance, caused by the deposition of a dark reddish yellow matter.

The second supposed stage is marked by the granular matter penetrating still deeper into the cortical substance, and which gradually increases till it invades the whole of the medullary substance of the kidney. This granular substance is of a greyish-red, or greyish-yellow colour, and has in many cases something of a *cheese*-like appearance. The kidney is now sometimes larger than natural, sometimes of the natural size, and sometimes, though rarely, diminished. Its consistency also varies, for if enlarged it is commonly softer than the healthy kidney, but if diminished it is for the most part firmer. Its colour, viewed externally, is sometimes a pale tint of the natural hue, but more commonly it is of a greyish-yellow or yellowish-red, and *mottled*. Its surface is also strongly granulated, and even rough. In this state, if the kidney be now injected, the matter of the injection does not, according to Dr. Bright, penetrate the cortical portion.

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The last stage is marked by the morbid granular deposit, besides invading the medullary substance, attacking the tubular portions of the kidney, so that the tubuli are often to a very considerable extent obliterated, and perhaps, with the exception of a single pencil of that structure, is entirely converted into one homogeneous degeneration. The kidneys are now, in some instances, of their natural size, but more generally they have contracted, and are smaller than usual; their surface is also now lobulated, pale, and granular, resembling the roe of a salmon. Their consistency also is sometimes softer and sometimes harder than natural; and Dr. Bright speaks of some instances in which they cut like cartilage.

Another disease of the kidney is Induration of its substance; and this alteration of its structure is consistent with its being enlarged or diminished in size, but more commonly the latter. Its colour also may be either natural or else darker or paler than usual. The induration may be partial or general, and when partial its most common seat is the tubuli, which often acquire an almost cartilaginous hardness.

The kidney is sometimes found softened, or in a state of *ramollissement;* and this alteration of the kidney, according as the organ is healthy or unhealthy, may be either pale or of an intensely deep red or liver colour.

Andral says, "I have found the substance of the kidney, whether pale or yellow, grease the scalpel." It is by no means unusual, however, to find steatoma of the kidney, and considerable portions of its substance either invaded by or else converted into fat.

*Periphrenitis* is an inflammation of the adipose, fibrous, and cellular tissue surrounding the kidneys. These parts are sometimes found simply injected, sometimes the seat of abscess, and sometimes gangrened. A remarkable case is narrated by Dr. Turner, in the *Transact. of the College of Physicians*, which destroyed a lady near 30, and yet, strange to say, she neither experienced any pain or difficulty in making water, neither was she aware of her urine being less copious than usual.

*Symptoms.*—Acute nephritis is an extremely rare disease, so that there is much doubt whether we are thoroughly possessed of its symptoms. Those mentioned by Dr. Baillie are as follows; but it will be seen that they are almost identically the same as those observed in the passage of a calculus, which makes it doubtful whether that eminent physician ever saw the disease. "When the kidneys," he says, "are inflamed, more or less pain is felt in the region of these glands, and the pain commonly shoots along the ureters. There is a sense of numbness down the thigh, and in the male there is often retractation of the testicle, or a feeling of pain in it. When one kidney is affected these symptoms are only felt on that side. The urine is voided frequently, and is sometimes of a pale, but more commonly of a deep red colour. The stomach sympathizes with this state of the kidneys, for it is affected with sickness and vomiting. The bowels are at the same time often costive, and subject to colicky pains. These symptoms are accompanied by more or less fever." "When pus is formed it may be known by its being mixed with the urine." Mr. Stanley's cases by no means bear out this description. He gives the case of a man who had retention of urine in consequence of a gonorrhœal discharge being stopped by injections. In this instance the kidneys were found extremely vascular and soft, with numerous minute depositions of pus throughout the corticular and tubular parts, and the infundibula and the pelves were likewise filled with pus. The principal symptom was severe pain at the fifth lumbar vertebra. In another similar case, but not quite so acute, the kidneys were found so dark-coloured as to be almost black, and at the same time remarkably flaccid. This patient died paraplegic, the loss of motion being complete, and that of sensation nearly so.

If nephritis passes to a chronic suppurative state, the pain in the loins is often severe, the appetite impaired, while pus is found, and often to a considerable amount, in the urine; and if a calculus or gravel be the immediate cause, the urine often contains large portions of those substances mixed with blood.

The other forms of chronic disease of the kidney have not as yet been distinguished from each other. For the most part they present no local symptoms, but give rise to dropsies, having no specific differences. The granular kidney, however, is always accompanied by albuminous urine, by universal anasarca, an impoverished state of the blood, and the many other singular phenomena of that disorder. It must be remembered, however, that although granular kidney is constantly acccompanied by albuminous urine, yet albuminous urine may accompany every structural disease of the kidney, or result from a mere disease of function.

*Diagnosis.*—Diseases of the kidney are to be distinguished from those of the bladder by the presence of dropsy, and also by the fact that the bladder is infinitely less liable to be the primary seat of disease than the kidney.

*Prognosis.*—Acute affections of the kidney are in all cases of grave prognosis. The chronic forms of these affections are perhaps consistent with life, but in every case they greatly impair it, and are ultimately the cause of premature death. When dropsy is established the patient recovers with difficulty, and is then liable to relapse.

*Treatment.*—The treatment of acute nephritis must be according to the ordinary laws of inflammation, or by bleeding, evacuants, and opiates. The young practitioner, however, should be warned that blisters in these cases are dangerous, and should be avoided. The neutral salts, with opiates, are perhaps admissible; but most writers recommend castor oil, manna, or other purgative substances which do not act so immediately on the kidneys. In chronic suppuration of the kidney it is plain that bleeding must be omitted. The other forms of diseased kidney, if they are ever cured, yield to the treatment pointed out for the cure of the dropsies which depend on them.

### Of Ureteritis and of Cystitis.

Ureteritis and Cystitis are inflammation of the ureter and of the bladder; but being parts so intimately connected and so rarely affected, it is thought best to unite them together. 138 cases are said to have died of these diseases in 1839.

*Remote Causes.*—The bladder or ureter is rarely acted upon by morbid poisons; and Louis has shown that ureteritis and cystitis rarely co-exist with diseases of other parts; for out of 500 persons dead of other diseases than those of the urinary organs, there were only



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five or six in which the mucous membrane of the bladder was injected, and only one in which a small ulcer of the same part was found; a remarkable circumstance, considering how frequently retention of urine is a symptom at the close of many diseases. It is well known, however, that cantharides, turpentine, and perhaps some other substances, act specifically on the bladder, and produce inflammation. Calculi, together with diseases of the kidney, are the most frequent causes of this affection.

*Predisposing Causes.*—The parties who suffer from these affections are principally adults and children who labour under calculi.

*Pathology.*—The mucous membrane of the ureter is liable to the diffuse, to the adhesive, to the ulcerative, and to the suppurative inflammations, and these may be acute or chronic.

The ureter is occasionally found to be highly vascular, and of a deep venous colour after the passage of a calculus; and this is supposed to prove that the mucous membrane of this canal is liable to diffuse inflammation. There are repeated instances of adhesive inflammation of this canal. Andral quotes a case in which all the internal surface of the ureter was covered with a layer of lymph similar to the membrane in croup; and in some rare instances the ureter has been found obliterated or transformed into a fibrous cord. A transverse canal has also in some instances been found connecting the two ureters; but whether this is a congenital formation or a consequence of a temporary obstruction of the ureter, is problematical. There are other well-marked effects of adhesive inflammation of the ureter, as when the delicate coats of this canal are increased, as in cases of severe chronic disease, to 4 to 6 lines in thickness. Suppurative inflammation also sometimes takes place in the ureter, and without breach of surface; for, in a case in which a calculus was found in the ureter, Cruveilhier says the part above the obstacle was filled with blood, *pus*, urine, and gravel. The different inflammations that have been mentioned sometimes terminate in ulceration, and the ulcers in some cases heal, for cicatrization of the mucous membrane has been met with. In other instances the ulcerated part has ruptured, and the patient has died in consequence of effusion of urine into the surrounding parts.

The ureter is occasionally much hypertrophied, especially if the bladder be diseased. It is also often greatly dilated, especially when a calculus is retained, or else when the bladder is so distended from the retention of urine as to obliterate the valvular fold which in health prevents the return of the urine towards the kidney. In these cases it is often so enormously dilated as to equal the size of a child's arm, and sometimes, according to Rayer, till it ruptures, the walls being from their great distension in a state of atrophy. In chronic inflammation the walls are often greatly thickened and *indurated*. No case is known of *ramollissement* of this canal.

The mucous membrane of the bladder is likewise liable to the diffuse, the serous, the adhesive, the suppurative, and the ulcerative inflammations, and these may be either acute or chronic. These inflammations may extend over its whole cavity, or be limited to some portion of it, and the part most frequently inflamed is that near and around the neck of the bladder. In this it follows the law of all hollow organs, or that it is most liable to be diseased at its orifices. There is also another reason for this part being more frequently attacked than the rest, or the occasional extension of inflammation of the urethra to this part.

"It is well known," says Dr. Baillie, that "the inner membrane of the bladder in the dead body hardly shows any vessels which are large enough to carry red blood in its natural state;" but when *diffusely* inflamed, it is crowded with a prodigious number of extremely fine blood-vessels, and among them may be seen small spots of extravasated blood. This state has many degrees, and the colour is usually of a venous red, while, in addition to this, the coats of the bladder generally are thickened. It may terminate by resolution, or it may pass into serous inflammation, or catarrh of the bladder. The mucus secreted in this latter disease is at first small in quantity and extremely fluid, but is deposited as the urine cools. At a further stage of the disease it becomes abundant and thickens, equalling or surpassing the urine in quantity, and which now resembles thick gruel, and is often mixed with blood, or gravel, or both. Andral has twice seen the internal surface of the bladder coated with lymph more than a line in thickness, and similar to the false membrane of croup. The lymph thus effused sometimes becomes organized; and in this manner calculi have become encysted and removed out of the reach of the sound. Dr. Baillie tells us that Dr. Ash met with a case in which the urinary bladder was divided (probably from this cause) into two chambers, which communicated by a small aperture with each other. The upper chamber was usually much distended with urine, so that a round tumor could easily be distinguished by the touch above the pubes.

Inflammation of the mucous membrane of the bladder often terminates in suppuration, and pus to a considerable amount may then be passed. Occasionally, instead of suppuration taking place at its free surface, an abscess forms: in either case ulceration may take place, sometimes superficially, and sometimes so burrowing as to perforate the bladder, and form a communication between it and the neighbouring parts, as the cavity of the abdomen, the rectum, or the vagina. When the communication is formed with the general cavity of the abdomen, the urine escapes into it and produces general peritoneal inflammation.

The mucous membrane of the bladder is liable to similar chronic inflammation, sometimes retaining its normal colour, and at other times being grey or *ardoisée*, brown, or black; and it has often acquired a double or even triple thickness. The follicles also, which are hardly visible in health, are now enlarged, and extremely palpable to sight. One of the most ordinary changes, however, in the bladder from its natural structure is hypertrophy of its muscular coat. In a natural state the muscular coat of the bladder, when it is moderately distended, consists of thin layers of muscular fibres running in different directions, and probably less than the eighth of an inch in thickness. The muscular coat of the bladder, however, is found in some cases half an inch thick, owing, for the most part, to its efforts to overcome some resistance, as an enlargement of the prostate, or the presence of a calculus or a stricture in the urethra to the passage of the urine. In some instances these efforts of the bladder to evacuate its contents have led to the mucous membrane being protruded through the intermuscular spaces, forming a pouch or hernial sac, in which a small calculus has been embedded, but this form of disease is extremely rare. The mucous coat of the bladder is also often greatly hypertrophied.

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The bladder may also be atrophied, so that when distended it is semi-transparent, and this may result from an atrophy of all its coats, or from a faulty development of the muscular coat. In some cases of congenital malformation the anterior portion of the bladder is wanting, and this is generally coincident with a defective state of the muscles of the abdomen, which are imperfectly united to the pubis. The bladder has also in some instances been altogether wanting.

The bladder is sometimes much *indurated* from chronic inflammation, while in other cases it has been found to have undergone the process of *ramollissement*, similar to that incidental to the stomach, when the slightest traction is sufficient to cause a rupture, and sometimes give rise during life to spontaneous perforation.

Dr. Baillie mentions having seen one case of *polypus* of the bladder so large as to fill up the greater part of its cavity. It was very irregular in shape, consisting of various projecting masses, but seemed pretty firm in its texture. Some of these tumors, says Andral, are hard and void of every trace of a vessel, while others are soft and vascular, and others again seem mere prolongations of the mucous membrane.

The bladder is sometimes enormously *dilated*, so as to occupy the lower part of the cavity of the abdomen, and to contain several quarts. It is in other cases so contracted as hardly to have any cavity, and will scarcely hold a few tea-spoonfuls.

*Symptoms.*—The symptoms of inflammation and of the other diseases of the ureter are probably the same as those of the similar diseases of the bladder, except, perhaps, that the pain is more strictly lumbar; and when these canals are greatly enlarged, it is possible they may be felt through the walls of the abdomen.

The symptoms of inflammation of the bladder are pain felt in the perinæum and above the pubes, accompanied with a fulness or swelling, also frequent attempts to make water, which is evacuated in small quantities and with great pain, or there is a total retention of urine, with a strong desire to void it. The rectum is affected, from its connexion with the bladder, with tenesmus, and the stomach likewise takes part in this disease, being affected with nausea or vomiting. In some cases these symptoms are accompanied with much constitutional irritation and by delirium. When pus is formed, it will be seen mixed in the urine evacuated. The slighter form of the disease, or cystirrhœa, is characterized by milder symptoms, which consist principally of local pain and irritation, and by the urine being loaded with mucus, which sinks to the bottom of the vase, mixed with a large quantity of sandy precipitates either of the phosphates, of the urates, or of both. It is remarkable that on this form of disease subsiding, that the patient often falls from disease of the lungs. The symptoms of the other forms of disease of this viscus vary only in degree from those which have been mentioned.

*Diagnosis.*—When the kidneys and ureters are diseased the bladder very constantly sympathizes with those diseases; and the affections of the bladder being much more painful than those of the ureters and pelvis of the kidneys, the sympathetic affection of the bladder is often mistaken for the primary disease. Morgagni first pointed out this fact, and gives a case in which, from these sympathetic pains, it was believed that the patient laboured under disease of the bladder; yet after death the bladder was found perfectly healthy, while the kidneys were extensively diseased, and filled with large calculi. Lowdell and also Howship give similar instances of the kidneys being diseased, when the symptoms of the bladder were so prominent as to be mistaken for the primary disease.

*Prognosis.*—The result of the acute forms of inflammation of the bladder or ureter is generally favourable. The chronic forms of cystitis, as of cystirrhœa, are more formidable, and often ultimately cause the death of the patient.

*Treatment.*—Bleeding does not greatly influence inflammatory affections of the bladder; but some authorities nevertheless direct moderate bleeding and purging, together with opiates, diluents, and the warm bath, as the best means of curing the very few acute affections of this viscus that we meet with. Chronic inflammation of the bladder, and especially cystirrhœa, is of very difficult cure, and often our best-directed efforts are unsuccessful. The state of the urine is perhaps one of the surest guides in our attempts to cure the patient; and if the urine be acid, the best medicines are the neutral salts or the pure alkalies, with opiates; while, if the urine be alkaline, or greatly loaded with mucus, the mineral acids are of the most service, combined with an opiate. Thus the infusi rosæ c. acidi sulph. dilut. ♏ij. to ♏v. c. magnesiæ sulphatis ʒj. c. tinct. opii ♏iij. to ♏v. 6[tis] horis is one of our best and most useful remedies.

The remedies which have been mentioned, though highly useful, yet frequently fail, and, in such cases, tonics often succeed, and of these salicine is the best, and gr. x. ter die vel 6[tis] horis may be given with great chances of success. It must be admitted, however, that much difference of opinion prevails as to the best tonic remedy, some preferring uva ursi, others pariera, others the turpentines, as the Canadian balsam, and others again the inf. diosmæ.

### Of Peritonitis.

Peritonitis is an inflammation of the serous membrane lining the abdomen, and covering the viscera contained in its cavity.

This disease was known to the ancients. It is not common; and if we take the numbers reported to have died of this disease, of hernia, and also of intussusception, the deaths from the two latter being generally caused by peritonitis, we find they amounted to only 757 cases in 1838, and to 895 cases in 1839, in England and Wales, which gives one death in about 370.

*Remote Causes.*—Inflammation of the peritoneum is caused by a few morbid poisons, as the paludal poison, and the poison of scarlet fever. Mechanical violence, as the kick of a horse, also the operation for hernia or the stone, or that of paracentesis, are frequent causes. Rupture of the intestine from ulceration, or the bursting of an abscess, or of an aneurismal tumor into this cavity, is also another class of causes. Errors of diet, and especially frequent intoxication, is an occasional cause, the disease termed *gin-colic* being a chronic inflammation of the peritoneum. Sudden and great changes of temperature are also causes, especially in women at the period of menstruation. Intussusception of the intestine, or strangulation of the intestine from hernia, or other accident, are also occasional causes. As a secondary disease it is frequently produced by hepatitis, splenitis, enteritis, and by cancerous and tubercular deposits in the subcellular tissue.

*Predisposing Causes.* — Children sometimes die of



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this affection after scarlatina, and also from strangulation of the intestines in consequence of congenital malformations. Peritonitis, however, is most common between the ages of 20 and 40. Women appear to die more frequently from it than men; and in 1838 the proportion was 57 men to 117 women, while in 1839 the ratio was 68 men to 115 women, or nearly in the ratio of two to one. This greater liability to peritonitis in the female sex arises perhaps from the great sympathy between the uterus and the peritoneum, a sympathy which is strongly marked, not only at the period of menstruation, but also at the time of parturition. At the latter period, in the opinion of many excellent practitioners, the remarkable fact occurs of puerperal peritonitis becoming contagious, and that the contagion spreads among puerperal women only.

*Pathology.*—The peritoneum is liable to the diffuse, the serous, the adhesive, the suppurative, the ulcerative, and to the gangrenous inflammations, and these may be either acute or chronic.

Acute inflammation of the peritoneum, as of all serous membranes, begins in the connecting cellular tissue, which becomes red and injected, and at length the same phenomena pervade the serous membrane itself. The colour of this membrane, when inflamed, like that of all serous membranes, is a bright arterial scarlet hue; the membrane being first dotted with a number of small red points, which become confluent, and form streaks and patches which in their turn coalesce; or a small central nucleus of inflammation may form and spread till the whole extent of the peritoneum is one entire bright scarlet. In addition to the redness, some interstitial deposit accompanies diffuse inflammation of the peritoneum, so that this membrane loses its transparency, and is thickened. The consistency also of the subcellular tissue is greatly impaired, and rendered easily lacerable, so that the peritoneum is now capable of being detached in considerable portions. This inflammation may terminate by resolution, or it may proceed, and serum be poured out, when serous inflammation is established. The quantity of serum effused may be trifling, not exceeding a few ounces, but occasionally it is large, fills the cavity of the abdomen, and constitutes inflammatory dropsy.

The next degree of peritonitis is the adhesive inflammation, when lymph may be thrown out oftentimes so loose as to float unattached in the serum, or it may be of such consistency as to unite opposite parts together, and of such extent as sometimes to form an adventitious membrane, covering the entire of the abdominal walls as well as the whole of the intestines. The period at which organization of the lymph thus effused begins has been determined by Mr. Hunter to be in about 24 hours. If the disease proceeds, pus is affused, sometimes not to a greater amount than a few ounces, but in other cases it amounts to many pints, or even fills the whole of the abdominal cavity. Ulceration of the peritoneum is infrequent, and generally takes place from without inwards, as from a perforating ulcer of the small or large intestines or from the rupturing of an abscess or other tumor. The peritoneum is also liable to mortification, either from high inflammatory action, or else from strangulation, as in hernia. In this case the part is of a reddish-purple or black, and is easily torn. The different acute inflammations described have been mentioned as though succeeding each other; but in many instances all these different forms co-exist in different parts of the peritoneum at the same time, and perhaps have been irregularly set up.

The chronic forms of peritonitis may be *chromatous* or *achromatous*, and the latter present some of the most curious phenomena incident to this tissue. The peritoneum, for instance, is often found to be white, opaque, and thickened, the subcellular tissue having become almost incorporated with the membrane, so that together they sometimes form a substance an eighth of an inch in thickness. The tissues are also now indurated, and much less easily detached; and, taking all these circumstances together, they show that the peritoneum must have been the seat in all probability of a chronic achromatous inflammation. A similar achromatous state of parts is often seen when serum is thrown out; and also when the intestines are found glued to each other and to the cavity of the abdomen by adhesive inflammation. It is remarkable, also, that pus in sufficient quantity to fill the abdomen is sometimes likewise found effused without the peritoneum being discoloured. It is from this process, also, that we occasionally find large cysts attached to the liver, or other abdominal viscus, filled with serous fluid.

The peritoneum is sometimes the seat of chronic *chromatous* inflammation. Thus we sometimes meet with chronic red diffuse inflammation, with chronic red serous inflammation, and with chronic red adhesive inflammation. The latter may be of various extent, and sometimes is so considerable that the false membrane which is formed covers not only the walls of the abdomen and of the viscera, but also the whole of the intestines, and even slips down between the convolutions. It is of a muddy brown or rusty colour, and usually contains much melanic matter, both in the web and at its free surface, and also much tubercular matter in the sub-cellular tissue. The membrane thus formed, like all new adventitious parts, readily runs into disease, and from this cause we often find the abdomen filled in these cases with serum or pus. In these chronic forms of chromatous peritonitis the subcellular tissue is less lacerable than in health, and Louis also mentions that parts which have been the seat of chronic peritonitis have a strong tendency to contract. Thus he has found the omentum corrugated, contracted, and folded up under the greater curvature of the stomach, till it has been so reduced as to be hardly recognizable and merely rudimentary. Besides the omentum, he has found the mesentery also contracted, that membrane being more or less shortened, till the intestines have been drawn up to the spine, and with such force, that an existing hernia has been sometimes completely reduced. The intestines themselves are also often contracted, and more frequently perhaps in their length than in their calibre, and in extreme cases they have been found to lose half or nearly so of their dimensions, when the valvulæ conniventes have been consequently drawn close to each other.

Experience has also shown that, although the structure of the peritoneum appears to be uniformly the same, yet certain parts of it are more liable to inflammation than others, as the convex surface of the liver or spleen, the right iliac fossa, the surface of the small intestine, and in females the broad ligaments, the Fallopian tubes, and the parts immediately adjoining them, as also the space covering the rectum and bladder. The parts the most rarely affected are those covering the stomach, bladder, the omentum, and the mesentery. It will be seen that the liability of different parts of the

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peritoneum to inflammation is in proportion to the liability of the organs they cover to become diseased, and that these partial inflammations are for the most part the result of sympathetic irritation. Dr. Hodgkin is of opinion that peritoneal gastritis is little more than a nosological distinction, and scarcely exists in nature. As his authority is great, it may be as well to mention that a man was brought into St. Thomas's, after having received a kick from a horse on the abdomen, below the umbilicus. He shortly died. The part of the abdomen where the injury had been received was not even discoloured, but there was extensive ecchymosis among the muscles beneath. The peritoneum was diffusively, adhesively, and suppuratively inflamed in different parts, while the peritoneum covering the stomach evidently partook of the general inflammation. A rupture also existed of the intestines.

The peritoneum is liable to become indurated, and more especially in those parts covering the spleen. There are two specimens in the Museum of St. Thomas's Hospital, in one of which the peritoneal coat of the spleen is cartilaginous, and in the other bony matter is largely deposited. It appears that this state is sometimes general, for "in one case," says Dr. Baillie, "I have seen a great many cartilaginous excrescences growing from the peritoneum. They are of a small size, most of them not larger than a garden pea. They were a little softer than the cartilages of the bones, but had the true structure of cartilage," p. 132. Ramollissement of the peritoneum is frequent, but not so frequent as of the mucous membrane.

Hydatids have occasionally been found in large numbers swimming freely in the fluid of ascites. They more frequently, however, according to Dr. Baillie and Dr. Hodgkin form beneath the peritoneum, and give rise to tumors, sometimes of an enormous size. Mr. Abernethy mentions having found a fatty tumor attached to the peritoneum.

*Symptoms.*—Peritonitis may be acute or chronic, partial or general.

Peritonitis is occasionally ushered in by some previous shivering and fever, but in many cases there are no preliminary symptoms.

If acute peritonitis is of that intensity which may terminate by resolution, or by effusion of serum, or of lymph, the patient complains of a severe pain in the abdomen, which is increased on pressure; he lies on his back, fearing to move. His pulse is from 90 to 120, and in proportion as it is frequent, so is it smaller; his tongue is coated, and his bowels constipated or regular. If serum be effused, that event can be determined by the fluctuation; or if lymph, by a rubbing sound heard under the stethescope. The course of these forms of acute peritonitis varies from a few hours to 10 or 14 days.

When acute peritonitis, however, is of that intensity that it will terminate in effusion of pus, the symptoms are infinitely more formidable. The pain in the abdomen is the severest that human nature can suffer. The patient indeed lies on his back, but his legs are drawn up and bent so as to relax as much as possible the abdominal muscles. Still, although the pelvis is fixed, he is restless, unable to bear the slightest pressure, not even the weight of a sheet, and is incessantly tossing his arms about in every direction. The state of his tongue and bowels are similar perhaps to what have been described, but his pulse is excessively small and rapid, varying from 130 to 150, while his stomach is often distressingly affected by retching and vomiting. These symptoms perhaps continue without intermission for 24, 48, 72, or more hours; when, with or without some previous shivering, pus is effused, and the pain from being agonizing is now bearable. The subsidence of the pain, however, is not followed by any amendment; on the contrary, a most alarming collapse succeeds, a cold clammy sweat breaks out over the body, while hiccup, and a pulse hourly increasing in frequency, proclaim the entire hopelessness of the patient surviving beyond a few hours.

When acute peritonitis is confined to the liver or other organ, the pain is often limited to that part, while the other symptoms vary according to the severity of the affection and the organ attacked.

Chronic peritonitis often takes place to a great extent, and without any great amount of suffering. The symptoms are rather those of abdominal soreness and uneasiness than of pain, together with a full but sometimes rapid pulse. The intestines indeed may be glued together, and sometimes pus has been found effused, without the patient suffering more than in ascites. When chronic peritonitis is partial, as of the liver or spleen, the patient often experiences a dragging pain, which is increased by change of position, and arises from the parts being suspended by adhesion.

*Diagnosis.*—The pain being greatly increased on pressure, and the pulse rapid, together with the general uneasiness and evident danger of the patient, readily distinguish peritonitis from colic or leucorrhœal pains.

*Prognosis.* — Partial peritonitis often terminates without in any sensible degree impairing the general health; thus we often find extensive adhesions of the liver without any marked symptoms. In every case, however, in which the structure of the peritoneum is thickened or otherwise impaired, the patient may recover, but generally relapses and dies of dropsy; for the peritoneum, like all other serous tissues, appears to possess little power of restoration after disease. Every attack of acute inflammation is of grave prognosis, and when pus is effused, it is uniformly fatal; neither will the patient recover if the peritonitis is caused by subperitoneal tubercles.

*Treatment.*—The treatment of acute peritonitis must be active, and there are few diseases in which the life of the patient is more completely in the hands of the practitioner. The activity of the treatment must be proportioned to the amount of pain and the rapidity of the pulse. In the milder forms of the disease, when the pain is bearable, and the pulse steady, and under 100, one bleeding from the arm, or 20 leeches over the abdomen, together with pil. hydrargyri. gr. v., n. m., and moderate purging with neutral salts, combined with an opiate, are sufficient to effect a cure. In the severer forms of disease, and with a tendency to effusion of pus, all these modes of treatment must be combined, and carried to a considerable extent. Thus 16 to 30 ounces of blood should be taken from the arm, and 30 leeches applied to the abdomen, and a poultice afterwards to encourage the bleeding. Bleeding, however, is not enough, for sometimes when carried so far as to affect the patient's head, and to cause temporary insanity, the peritoneal inflammation is not subdued. It is necessary, therefore, to have recourse to mercury, and with a view to affect the mouth; and five grains of calomel, combined with half a grain of opium, so as to

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give the patient some relief from pain, should be exhibited every four, six, or eight hours, according to the intensity of the disease. As soon as the mouth is affected the patient is relieved, and at this point the mercury should be omitted, and the patient moderately purged with neutral salts, combined with an opiate, and he often recovers.

The treatment of chronic peritonitis must be directed by the same principles; but we should be content with effecting a present alleviation of symptoms, and without attempting the removal of the mischief which has already occurred; for in patients that have laboured under chronic peritonitis, and survived many years, the peritoneum has still been found opaque, thickened, and silvery, so that in all probability these alterations are permanent.

The diet of the patient in the acute forms of peritonitis should be rigidly slops.

### Of Inflammation, and other simple Organic Diseases of the Respiratory Organs.

#### Angina—Cynanche—*Sore Throat*—

Is an inflammation of the parts constituting the fences: 659 cases are reported to have died in the year 1839 of quinsey, a popular name for sore throat.

*Remote Cause*.—The fauces are unquestionably acted upon by many morbid poisons, as that of scarlet fever, of small pox, of syphilis, and of influenza. Indeed the generally contagious nature of sore throats would lead us to believe that they are a class of disease determined in 19 cases out of 20 by some ephemeral or other morbid poison. In a few cases it appears to arise from cold, while a few more are caused by children accidentally drinking boiling water out of the spout of a tea-kettle. Occasionally it is produced by mercury or by mineral acids taken for the purposes of self-destruction.

*Predisposing Causes*.—Children from a very early period of life are exceedingly liable to sore throats; it is also very common in early adult age, but after 50 is comparatively infrequent. The sexes appear to suffer in nearly equal proportions. For in the year—

1838 . . 206 men and 206 women
1839 . . 353 ,, 306 ,,

are reported to have died from this affection. The seasons most pregnant with this disease are spring and autumn.

*Pathology*.—The common law of sore throats is that the poison produces fever, and after a few hours the patient complains of sore throat, which is of various intensity, the mucous membrane of the fauces being liable to the diffuse, the serous, the adhesive, and to the ulcerative inflammations, the latter sometimes terminating in gangrene. The substance also of the tonsils and uvula is likewise liable to all the inflammations that have been mentioned, and also to the suppurative inflammation, and these inflammations may be acute or chronic.

The mucous membrane of the fauces is often diffusely inflamed, when the patient complains of the throat being hot, rough, and dry, and, on examining the mucous glands they are found enlarged, the faucial membrane redder than usual, and all secretion stopped. This inflammation may terminate by resolution, or it may proceed, and it is probable, in a few cases, as in salivation, serum may be effused. More commonly, however, lymph is thrown out first in points, which sometimes coalesce, covering a considerable space. The more usual termination of these inflammations, however, is by ulceration at the surface of the membrane. When ulceration takes place, a slough forms, and is detached at various periods, or from a few hours to six or seven days. The ulcers are of very various forms, round or oval; sometimes entirely superficial, and then again deeply burrowing; and as inflammation of the tonsils is generally of a low character, they sometimes terminate in gangrene. The parts of the membrane most prone to ulceration are those covering the anterior and external surfaces of the tonsils and uvula, and also the posterior edges of the palate. When, however, the uvula is affected, it should be remembered that the ulceration may commence at the posterior surface, so that, in bad cases, that part may almost slough away unperceived, unless closely watched.

Besides the mucous membrane, the substance of the tonsils and uvula may inflame, and in this case the tonsils are red, loaded with blood, and moderately swollen, while the uvula is not only red and swollen, but greatly elongated, so that it rests on the base of the tongue, causing a most disagreeable sense of titilletion. The disease may advance, and lymph or serum be thrown out, and in this case the tonsils are often greatly swollen, so as in some instances almost to occlude the passage of the fauces. The diagnostic symptom between the effusion of serum and of lymph is that, in the latter case, the tonsil remains often permanently enlarged, the lymph effused having been organized. In a very few instances an abscess forms in the tonsils, which ultimately ruptures and discharges a greater or less quantity of pus. It generally happens that both tonsils are affected, but occasionally the inflammation is limited to one tonsil.

In chronic inflammation of the tonsil the same phenomena are seen, but the course of the disease is slower, and the colour of the parts less vivid, and in general differing little from their natural tint.

The inflammation of the fauces, whether acute or chronic, not unfrequently extends to the pharynx; and its mucous membrane may in like manner take on the diffuse, serous, adhesive, or ulcerative inflammations. The inflammation also may commence in the subcellular pharyngeal membrane, and an abscess occasionally forms in that part. In a smaller number of cases, by an extension of the original disease, the epiglottis, glottis, and even the larynx are affected. In bad cases, as after severe scarlatina, it may also spread to the Eustachian tube, and cause suppurative or other inflammation of the mucous membrane of the internal ear. It sometimes also extends up the nasal passages, by which respiration through those passages is much impeded or rendered impossible, so that the patient breathes with his mouth open.

The tonsils have also been found to contain cysts, hydatids, and also to be the seat of calcareous formations.

*Symptoms*.—The different degrees of intensity which attend this affection allow us to divide sore throat into angina mitior and into angina gravior.

Angina gravior is usually preceded by some shivering and fever, which having lasted a few hours, the patient has the sensation of a sore throat. He finds deglutition difficult and painful, and what he attempts to swallow is perhaps rejected through the nostrils; his voice is altered, being hoarse and nasal, and he can hardly breathe through his nose; his ears are also painful, and he finds it troublesome to free his throat from the viscid matters

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which adhere to it. The fever does not abate on the appearance of the local symptoms, but usually continues till the sloughs are detached, after which, if the case be properly treated, it declines, and the patient rapidly recovers. If, however, he be improperly treated, the patient often becomes delirious, showing under these circumstances that a poison still remains in the system, and acts on the brain and its membranes. Indeed the degree of prostration which often attends sore throat is so constantly out of all proportion to the local lesion, that it is impossible not to come to the conclusion that the angina very constantly results from a cause acting on the system generally. The fever, however, when the case is properly treated, generally subsides in three or four days, seldom lasts more than a week, after which the patient rapidly recovers, though in other cases that event may be delayed for two, three, or four weeks. This form of disease admits of two varieties, or that in which the tonsils are greatly swollen, and the ulcers for the most superficial, and that in which the tonsils are greatly loaded with blood, little swollen, and the ulcers deep and burrowing. The latter only is dangerous.

The symptoms of angina mitior differ merely in degree from the former, the fever being milder, and the tonsils only moderately swollen, and the ulcers always presenting a healthy appearance. This form of disease almost always terminates in a week or ten days.

The chronic forms of the disease are unaccompanied with fever, and when the result of simple inflammation, the tonsils are usually greatly enlarged, and the seat of one or more superficial ulcers, often covering its whole surface.

*Diagnosis.*—As the parts are visible, no mistake can possibly take place with respect to the existence of this disease, although it may be difficult to determine its exact cause.

*Prognosis.*—The instances are extremely rare in which a patient falls from angina.

*Treatment.*—The treatment of angina is extremely simple, and is determined by the state of the tonsils. When the tonsil, for example, is little swollen, there is hardly a case which resists four ounces of wine daily mixed with water, arrow-root, or sago, together with attention to the bowels, and this whether fever be or be not present. On the contrary, if the disease be neglected, or the patient be badly treated and bled, the fever is increased, delirium ensues, and the ulceration spreads, involving the possibility of its terminating in gangrene. Again, if the tonsil be greatly enlarged, a few leeches should be applied externally to the upper part of the throat, and these should be followed by a poultice and by gentle purging, with the mildest cathartics. On the contrary, should this state of parts be neglected, or the patient treated by tonics, the mischief is not so great as in the former case, but the fauces may be closed, or nearly so, and perhaps remain permanently enlarged, or an abscess may form, and in either event the condition of the patient is for a time rendered highly distressing, and in appearance even dangerous. Many practitioners are in the habit of using gargles, or blisters, or caustic; but these are for the most part unnecessary, often injurious, and partake greatly of the "nimia diligentia medicorum." In every case the patient should be strictly debarred from animal food till the throat be healed.

If, after the throat is healed, the tonsils should remain permanently enlarged so as to affect the speech, something should be done to effect their diminution; and perhaps the removal of a very thin slice is the most efficacious, for although often intractable to all other treatment, they frequently yield to this operation. Mr. Liston indeed states, that he has practised this method on public singers, and without in any degree impairing the compass, tone, or flexibility of their voices. When the uvula is permanently elongated from a similar interstitial deposit, astringent lotions are of little efficacy, and the removal of a portion either by the knife or ligature appears to be the only remedy.

EPIGLOTITIS—LARYNGITIS—*Croup*—

Is an inflammation of the mucous membrane of the epiglottis, glottis, or larynx, and very commonly of all those parts.

It has often excited much surprise that a disease so distinctly marked in its symptoms should not have been accurately described before the middle of the XVIIIth Century, when Dr. Horne published a treatise on the suffocatio stridula, or croup, in 1765. This defect, perhaps only explicable on the ground of the little encouragement and fostering patronage with which the labours of the physician have been at any time cheered, is now supplied, for the disease is well known in this country, and is of great fatality; 4192 persons being reported to have died of it in England and Wales in the year 1839, or perhaps one child in twelve dies of this complaint.

*Remote Cause.*—There are some morbid poisons which unquestionably act on the larynx, as the paludal poison; also the poison of scarlet fever, of the hooping-cough, of the small-pox, and of syphilis. The annals of medicine also are rich in descriptions of epidemic and endemic croup, whence it would appear this latter affection was generally produced by some unknown poison. This is so much the case, that M. Baudelocque, physician to the Hôpital des Enfans, where 3000 cases are admitted annually, says, that sometimes for three years together he has not seen a single case, while M. Guersent's experience has been to the same effect. In other years, however, they have witnessed large numbers affected with this disease. These facts appear inexplicable from the mere play of atmospheric vicissitudes, and appear strongly to point to a specific cause. Sudden changes, however, from heat to cold, an easterly wind, the irritation of teething, are the other principally alleged causes of laryngitis. As a secondary affection, it arises in the adult from phthisis, from disease of the œsophagus, and from the pressure of an aneurismal or other tumor.

*Predisposing Causes.*—No age is exempt from laryngitis; but age greatly influences the occurrence of it. Perhaps the statement of Andral is an approximation to the truth. Thus, out of 288 cases he found 237 occur from birth to seven years old; and from this period up to 70, the deaths from laryngitis, taking decennial periods, were nearly in equal numbers in each division. As to the effects of sex, out of 543 children, 293 were boys, and 218 girls, the sex of 32 not being determined. Of adults that died of laryngitis in England and Wales in 1839, 40 were males and 22 females.

This difference of liability between the male and the female is probably merely owing to difference of exposure to the exciting cause. Mr. Farr calculates that deaths in towns from croup, compared with those from croup in the rural districts, are as 1 to 1·31.

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*Pathology*.—The mucous membrane of the epiglottis, glottis, and larynx, is liable to the diffuse, the serous, the adhesive, to the suppurative, and to the ulcerative inflammations; and these inflammations may be either acute or chronic.

When the mucous membrane of the parts which have been mentioned in diffusely inflamed, its colour is in general of a deep venous red, while from some interstitial deposit it becomes thickened. This state of parts may occupy the whole larynx, or may be limited to its superior portion, to the chordæ vocales, or to the ventricular cavities; but when general and excessive, death, with all the symptoms of croup, has occurred, without the slightest effusion of lymph or other morbid product.

Diffuse inflammation may terminate by resolution, or it may proceed, and serum or pus be effused. These latter inflammations often take place in these parts, without any grave or serious accident arising to the patient, and almost without leaving any pathological phenomena behind them. When, however, the disease terminates by ulceration, or the throwing out of lymph, the case is often fatal, and the lesions extremely well marked.

Ulceration of the larynx is seldom seen in children, but is not unusual in the adult; and it is from this form of laryngitis that persons above the age of 10 years commonly die when afflicted with this disease. The number and size of the ulcers vary greatly; sometimes they are small and numerous, while, in other cases, there is only one, and that of considerable size, occupying the whole of the ventricle, or even a larger portion of the larynx. The base of the ulcer is generally the fibrous tissue, but sometimes it penetrates much deeper, involves the thyroid cartilage, and occasionally even perforates it, so as to produce a fistulous opening communicating externally, the voice being entirely lost, except an obturator be placed over the orifice. The principal seats of the ulcers are the epiglottis, the chordæ vocales, the ventricles, the angle formed by the union of the two thyroid cartilages, and posteriorly by the portion between the two arytenoid cartilages.

The most remarkable pathological phenomena of croup, however, are those caused by the *adhesive inflammation* terminating in the effusion of lymph, and the formation of a false membrane, a form of inflammation which, though sometimes seen in the adult, is nevertheless almost peculiar to children. The membranes thus formed vary much in thickness and consistency. Some are so thin that the mucous membrane is readily seen through them, while others are many lines in thickness, exceeding even that of the mucous membrane itself, and consequently opaque. With respect to their consistency, some are so little coherent, that they are almost diffluent, while others can be detached for a considerable extent without rupturing. The false membrane, though occasionally only partial, yet more commonly embraces the entire circumference of the larynx, forming a complete hollow cylinder, adapted to the walls of the larynx. The membrane is in most instances limited to the larynx, but in some cases it extends down the trachea to the bifurcation, while in a very few cases it reaches even to the minutest branches of the bronchi. M. Hussenot says, of 120 cases he examined, in 78 it did not extend beyond the larynx, while in 42 cases it invaded the trachea or bronchi. The membrane thus formed is, in a few instances, removed by the cough, but more generally it adheres with so great tenacity that Gendrin conceives that it can only be detached by a thinner and more serous secretion taking place from the mucous membrane beneath it, which loosens and displaces it. No well-authenticated case exists of this false membrane having been found organized.

Besides inflammation of the mucous membrane of the larynx, &c., at its free surface, the connecting cellular tissue is probably the occasional seat of all the inflammations that have been mentioned. Thus the loose cellular tissue around the glottis is often seen red, injected, and thickened, and likewise the seat of extensive serous effusion, greatly contributing to the death of the patient. Bouillaud and Andral have also both seen abscesses of the submucous cellular tissue of the larynx. Abscesses have also formed in the superior portion of the œsophagus which have burst into the larynx.

The mucous membrane of the larynx, in addition to being the seat of inflammation, is sometimes affected with *Ramollissement*. We are astonished to find, says Andral, on examining individuals (*Anat. Pathol.* tome ii. p. 473) who have been a long time hoarse, no other lesion of the larynx than a partial softening of the mucous membrane, especially of the chordæ vocales, and of the base of the ventricles, nearly denuding perhaps the resplendent fibres of the thyro-arytenoidean ligaments, which are now merely covered with a red or whitish pulp.

In a very few instances polypous growths take place from the mucous membrane of the larynx, as from that of the pharynx or nose, and which gradually increasing, at length destroy the little patient.

Besides inflammation or other disease of the mucous membrane of the larynx taking place, the parts beneath are often the seat of many different affections. Thus the muscular tissue of the larynx, arranged so beautifully in distinct fascia, and fulfilling such important functions, is sometimes found atrophied, hypertrophied, softened, or more or less completely destroyed, and causing marked alterations of the voice. It is seldom that the os hyoides is found diseased; but in a case that died some years ago in St. Bartholomew's Hospital, with symptoms of most severe laryngitis, that bone was found necrosed and separated at its apex, so that the soft parts had fallen in, and the patient died suffocated.

The cartilages of these parts also are often the seat of disease. Thus the cartilage of the epiglottis often loses its normal form in consequence of inflammatory contraction of the mucous membrane covering it. This cartilage also is sometimes from the same cause much less moveable than in health, and in some very few instances it has been seen ossified. In other cases it has been removed more or less completely by ulceration, commencing either within itself, or else extending from the mucous membrane. The other cartilages of the larynx, as the thyroid and cricoid, are often similarly diseased, and may be ulcerated, perforated, or necrosed, and in some cases suppuration has taken place at the articulation of the cartilages, and the ligaments been destroyed.

Ossification of the thyroid and of the cricoid cartilages is a normal phenomenon in old persons, but it may take place prematurely, and then it is morbid. No case, however, is known of ossification of the arytenoid cartilages.

*Symptoms*.—Croup may be preceded by sore throat,

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by catarrhal symptoms, or by a short dry cough, or it may occur *per se*, and without the general health being sensibly impaired. In either case the attack commonly takes place during the night, the sleep of the child, which was perhaps more or less agitated, being interrupted by fits of hoarse coughing. These become more frequent, the respiration more difficult, and marked by a peculiar wheezing, which has been described as varying from the sound of an inspiration forcibly made with a piece of muslin before the mouth, or to air passing through a brazen tube. The little patient also feels a sense of constriction about the throat, which she marks by carrying her hand often to it, and grasping the larynx. After the paroxysm has lasted some hours, there is an interval of ease, which perhaps lasts for some hours, till the excitability of the parts is again accumulated.

By the end of the second or third day, sometimes sooner, the tongue becomes white, the heat of the body increased, the pulse frequent, the countenance livid and distressed. From this point the disease now rapidly advances, the croupy sound attains its height, and Dr. Horne describes it as "vox instar cantus galli;" others have compared it to the noise which a fowl makes when caught in the hand; while the child often puts its fingers into its mouth, as if to pull away something which obstructed the passage.

As the disease draws towards a close the paroxysms become more frequent, the cough more severe, the pulse more rapid, suffocation more imminent, and the extremities cold and livid. The final close of the disease is often by convulsions, sometimes almost tetanic; and Dr. Ferriar once was present when the struggle was so violent that after death the corpse in a great measure rested on the occiput and on the heels.

It is seldom that children expectorate; but in happier cases than the above, mucus, tinged perhaps with blood, is coughed up, and later perchance the false membrane is detached and thrown up, and the patient recovers.

The croup which has been described is of the acutest kind, but in many cases its course is much more chronic, the symptoms generally milder, and the intervals of ease longer and more complete; and during which the breath is free, the child cheerful, and the appetite good. In the course of a few days, however, a violent paroxysm seizes the child, and destroys him with every appearance of one strangled.

The internal fauces, as the tonsils, uvula, velum pendulum palati, are sometimes seen inflamed and ulcerated, while in other cases the fauces are healthy.

Several cases are on record of croup having terminated in 24 hours; more frequently, however, the child lives to the third or fourth day, and in chronic cases much longer.

According to Barth, on the stethescope being applied to the larynx, we hear a sort of "tremblotement," as if a moveable membrane was agitated by the air; and he considers this phenomenon as an unerring evidence of the existence of a false membrane in the larynx.

Laryngitis in the adult is marked by the same difficulty of breathing, the same lividity of countenance, the same constriction of the throat, by the same paroxysmal attack, and by the same exemption from any severe constitutional affection. The voice, however, instead of being sharp and shrill, is generally deep and hoarse, although sometimes altogether lost; differences depending perhaps on the greater size of the glottis, and on the fact of the parts being the seat of ulceration, rather than of the effusion of lymph. At length the patient is cut off in one of the paroxysms. The duration of this disease, when acute, is short. The celebrated Dr. Pitcairn died on the fourth day from the first attack, and Sir John Hay, physician to the forces, died within the same period. More commonly, perhaps, the disease passes into a chronic state, when the patient may survive many weeks, or even months.

Polypus of the larynx is a rare disease. In one case a child between three and four years old had laboured for more than two years under attacks of croupy breathing, but without greatly suffering in her general health. At length her voice became permanently stridulous and shrill, with severe paroxysms of difficult breathing; in one of these she died, when a small polypus about half an inch in length, and adhering by a pedicle, was found growing from the posterior portion of the larynx.

Ossification of the cartilages alters the timbre of the voice and deepens its tones, but does not produce any general or local inconvenience.

*Diagnosis.*—Inflammatory croup in the child is to be distinguished from false croup by the latter being sudden in its attack, and by the voice being extremely hoarse instead of shrill, the glottis not being obstructed by any adventitious membrane. In the adult we must distinguish inflammatory laryngitis from sympathetic laryngitis, and from that caused by the pressure of an aneurismal or other tumor, as enlarged glandulæ concatinatæ.

*Prognosis.*—The danger of croup is to be determined from the violence of the local symptoms and the frequency of the paroxysms, rather than from the constitutional symptoms. Children, however, seized with croup recover in a very small proportion.

The adult also, after ulceration has taken place, seldom recovers; but his case is not so hopeless as that of the child.

*Treatment.*—When the croup in children commences in the larynx its course is so rapid and so fatal that the measures for its suppression must be early and energetic. Bleeding, and especially local bleeding, should be employed, and in most cases to a considerable extent, and two to twelve leeches, according to the age of the patient, should be applied over the larynx; and after these have fallen off the bleeding should be encouraged by the application of a linseed poultice to the throat. This first bleeding often gives great relief, and sometimes stops the disease; but if not, the leeches, after a few hours, may be repeated. As soon as some relief is obtained a blister should be applied, and after that is removed the part should be dressed with strong mercurial ointment. Besides this local treatment it is usual to give mercury by the mouth; some practitioners even give it as largely as one to two grains every hour, and Brettoneau says he has given as much as three scruples in twenty-four hours. This ultra active treatment, however, looking to the great mortality attending croup, can seldom have been successful; and it may be doubtful whether in many instances it has not accelerated the fatal termination.

In addition to bleeding, blistering, and mercury, many practitioners prescribe emetics; first, because their depressing effects and the large evacuations they produce lower the vital power and favour the resolution of the inflammation; and again, because the effort of vomit-



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ing may be the means of detaching and of expelling the false membrane, should it have formed.

Bleeding, blistering, and mercury, although the rule of treatment in idiopathic infantine croup, are, for the most part, entirely inefficient in those cases in which the affection begins in the fauces, as in the case of many epidemics, and especially after scarlatina. In these cases the best treatment, if the false membrane be not already formed, is to treat it as a case of scarlet fever, and to relieve the throat by the application of a few leeches, and then to support the little patient with a moderate quantity of wine diluted with water. Several cases recently treated in this manner all recovered, while two that were extensively bled died. If the false membrane has formed, perhaps an emetic affords the only chance of relieving the patient.

In the adult the pathological phenomena are somewhat different from those of childhood, the mucous membrane of the larynx being for the most part ulcerated, and the cartilages often diseased. Large bleedings, consequently, as they have little tendency to heal the ulcerated part, or to remedy the affection of the cartilages, have little or no beneficial influence over the disease. Dr. Pitcairn was once copiously bled, and Sir John Hayes was bled from 30 to 40 ounces, but they both died. Local bleeding may be employed to relieve the fulness of the throat, but beyond this bleeding is of little value. Mercury, however, appears a powerful resource in these cases; and mercury, introduced either internally or by inunction, so as to affect the mouth, uniformly gives relief as soon as the constitutional affection is established. Unhappily, however, the amelioration is transitory, for almost as soon as the mouth is healed the symptoms return, and the patient again lies in imminent danger. Another salivation produces another cessation, but equally temporary, and the patient ultimately falls. It may be problematical whether we possess any more powerful remedy for this affection; but in two cases in which the disease was very marked, so much so that in one there was a fistulous opening externally, the oxyde of platina, exhibited in doses of two grains three times a day, cured the patients, after mercury and many other remedies had failed. A third case has also been treated in the same manner with equal success very recently. This substance acts as an emetic in doses of grs. iij. to grs. v. Platina, however, is quite useless when the laryngitis is a secondary disease, and caused by phthisis or syphilis; it is also useless when the laryngitis depends either on a diseased state of the cartilages, or of the os hyoides.

The medical treatment of laryngitis, both in the child and in the adult, is so frequently onsuccessful that tracheotomy has often been had recourse to as the means of prolonging life, and consequently as affording an additional chance of the patient's recovery. Guersent has performed this operation repeatedly at the Hôpital des Enfans, but almost always without success; on the contrary, Trousseau states he has saved one-third of his patients. Perhaps the experience of the profession is equally discordant on this point; for those who operate early, and perhaps often most unnecessarily, contend they save some portion of their patients, while those who wait till a case is made out before they resort to this experiment for the most part lose all their patients. The cause of death after the operation is often extremely perplexing, for the patient, whether a child or an adult, often revives, breathes freely, and the local inflammation from the use of the knife is generally trifling, and yet the patient dies. Some physicians attribute this result to congestion and disease of the lung itself; but as the patient often lives for three or four days tranquil, and almost without cough, this hypothesis does not appear satisfactory. The fatal result, therefore, seems rather to depend on a cause acting generally on the system, and which destroys the patient. It must be admitted, however, that in a very few instances, when the croup perhaps is the result of a local cause, that the patient, whether a child or an adult, does recover. Dr. James Johnson lately mentioned, at the Medical and Chirurgical Society, no instance of a man who had lived 27 years breathing through a canula inserted low in the trachea. It should be remembered that in the adult the cricoid cartilage may possibly be diseased, and consequently it is desirable the incision for tracheotomy should be as low down as possible.

### Of Tracheitis.

The remote and predisposing causes of this affection are nearly similar to what have been mentioned as producing laryngitis. As to its pathology, the mucous membrane of the trachea is liable to the diffuse, the serous, and the suppurative inflammation, and all these occur frequently in the course of a common cold, and without any marked or dangerous symptom. In a very small number of cases lymph is found effused on the free surface, but most likely this form of disease is always an extension of laryngitis or of bronchitis. Ulceration of the trachea is extremely infrequent, except in phthisis, when the ulcers occupy, by a species of election, the posterior portion of this canal. When they are primary they sometimes are seen in other parts of the trachea.

The cartilages of the trachea are rarely the seat of disease; but they also are liable to be inflamed, perhaps ulcerated, and certainly necrosed. A case of this kind occurred some years ago in St. Thomas's Hospital: the patient, a stout young woman about 20 years of age, laboured under much hoarseness and difficulty of breathing, but her general health was good. She died suddenly in the night, and as was supposed from spasm of the glottis. On examining her, a small ulcer was found in the mucous membrane of the trachea, and beneath it the cartilage was necrosed and broken. Andral once met with a case of abscess of the thyroid gland, with complete destruction of the cartilages of the trachea, and the pus of the abscess had made its way so as to have raised up the tracheal mucous membrane. Portal also gives a case in which hydatids of the thyroid gland perforated the trachea, and suddenly destroyed the patient by asphyxia. A larynx was lately shown at the Medical and Chirurgical Society of which the three upper cartilages appeared to have been absorbed, and that without any apparent cause. The patient died at length asphyxiated. The cartilaginous rings of the trachea are occasionally seen ossified, but even this is a very rare circumstance.

### Of Pneumonitis.

Pneumonitis is an inflammation of one or more tissues of the lungs. Thus the bronchial membrane may be inflamed, causing *bronchitis*; or the substance of the lung may be inflamed, causing *pneumonia*; or the pleura may be inflamed, causing *pleuritis*; and two or

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more of these inflammations may exist at the same time. The number of persons reported to have died of these complaints in England and Wales, in 1839, amounts to 20,402; or from bronchitis, 1663; from pneumonia, 18,151; and from pleurisy, 588; thus causing the death of about one person in sixteen.

The class of disease now about to be treated of was well known to the ancients, but we owe much to Avenbrugger and Laënnec for having studied the physical properties of the chest, and demonstrated the great changes the natural sounds heard by auscultation or produced by percussion undergo when the different tissues of the lungs are affected, and which have enabled the moderns to give a precision to their diagnosis of disorders of the chest entirely unknown to those who have preceded them.

*Remote Causes.*—Inflammatory affections of the lungs are caused by many morbid poisons, as the poison of typhus fever, of the measles, of small-pox, of influenza, and also of the paludal poison. It is probably owing to the action of the last poison that, although as a general principle diseases of the chest diminish in frequency as we approach the equator, yet that in the West Indies the inflammatory pulmonary affections greatly exceed those of this country. In the more northern climates these affections are intimately connected with atmospheric vicissitudes, as cold and wet; at least we find them prevailing most in those months in which the temperature is lowest. Thus, in the winter quarter, 3891 persons fell from these causes; in the spring quarter, 2823; in the summer quarter, only 2057; and again in the autumnal quarter the numbers amounted to 3799. Mechanical injuries, as blows, especially if a rib be fractured, are also occasional causes of pneumonitis. As a secondary affection, pneumonitis may be caused by phthisis, by the presence of hydatids, or by the pressure of an aneurismal, cancerous, or other tumor.

*Predisposing Causes.*—Young children are often attacked with pneumonitis; adult age is still more liable to that disease, that period of life being most exposed to all the great moral and physical causes of disease, as well as to the action of many morbid poisons. Old age is most liable to that form termed bronchitis; and this arises from the decline of the powers of life, which often first shows itself by disease of the organs supplied by the eighth pair, as the heart, the lungs, or the stomach. It appears that men are something more exposed to all these affections than women. Thus there died in

| | 1838 | | 1839 | |
|---|---|---|---|---|
| | Men. | Women. | Men. | Women. |
| Of Bronchitis . | 1,193 | 874 | 916 | 747 |
| Pleurisy . | 329 | 253 | 342 | 246 |
| Pneumonia . | 9,687 | 8,112 | 10,000 | 8,157 |

The effects of those many causes which deteriorate the health of the inhabitants of towns are extremely marked in the production of pneumonitis, for, out of a million of persons living in towns, 2028 died; while out of a similar number of agriculturists, only 905 fell in 1839. Having thus spoken of the general and predisposing causes of pneumonitis, it will now be necessary to speak of the pathology of the different tissues composing the lung, and first of *bronchitis*.

*Pathology of Bronchitis.*—The mucous membrane lining the bronchial tubes is liable to the diffuse, the serous, the adhesive, the suppurative, and to the ulcerative inflammation, and these may be either acute or chronic.

In red diffuse bronchitis we find the inflamed portions of the mucous membrane of a deep venous red, and this redness may be general or partial, and when partial it may be in spots or streaks, determined perhaps by the cartilages. This inflammation, when at its height, is probably void of secretion, and the membrane consequently dry, and giving rise to the "catarrhe sec" of Laënnec. This may at first terminate by resolution, or it may pass into the serous inflammation, when the mucus first secreted is thin, watery, and even frothy like saliva, but which subsequently becomes thicker and more consistent; and again it may take on the suppurative inflammation and pus be effused. In a very few cases lymph is thrown out, forming a false membrane, and in a still smaller number (except in phthisis) ulceration of the bronchial membrane occurs, and this may take place from within outwards, or from without inwards, but the latter is by far the most common.

Most authors affirm that the bronchial membrane, when inflamed, is thickened, and more particularly at the points of division, and that the various râles depend on the degree of thickening of this membrane, slight alterations of diameter producing great alteration of sound. Andral even says that the mucous membrane of the smaller bronchi may be so thickened as to cause a complete obstruction. This thickened state of parts, however, is very difficult to demonstrate, and many intelligent pathologists have never witnessed it, and consequently attribute the different râles so often heard in bronchitis to spasmodic contraction of the circular fibres.

The bronchitis may affect one lung, or both lungs, or a part of a lung, and the upper lobes are more commonly affected than the lower ones. The larger bronchi are also supposed to be more commonly inflamed than the smaller ones.

Although it is by no means uncommon to find red or chromatous inflammations of the bronchial membrane, yet it is equally common to find various forms of achromatous inflammation. Thus nothing is more usual than to find the mucous membrane beneath a purulent secretion either natural in colour or else paler than in health, so that the most profound pathologist is unable to distinguish the morbid from the healthy state.

The cartilages of the bronchi are occasionally found dilated, forming a small bronchial pouch. They are also sometimes hypertrophied, and, instead of points, form imperfect rings, as in the larger bronchi or in the trachea. The cartilages also, in some rare instances, have been found ossified; and Andral gives a case of an old man dead at Bicêtre, whose lung presented the ramified appearance of a piece of hollowed coral, or of the branches of a tree; he considered these to be the last ramifications of the bronchi in a state of ossification. The cartilages of the bronchi, when the long has been long collapsed, appear to be absorbed, hardly a trace of them being discoverable.

Hydatids have occasionally been coughed up from the lung, perhaps formed in the bronchial membrane in the same manner as in the mucous cavity of the uterus or bladder. Some very rare instances are also given of polypous growths from the bronchial membrane.

*Pathology of Pneumonia.*—The substance of the lungs is liable to the diffuse, the serous, the adhesive, the purulent, the ulcerative, and to the gangrenous inflammations; and these inflammations are all *acute*,



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chronic inflammation of the substance of the lungs, according to many writers, being unknown.

The characters of diffuse inflammation of the substance of the lungs are the lung being more loaded with dark venous blood than usual, and its texture being more easily broken down than in health; air, however, still penetrates the bronchial cells, and consequently the lung still crepitates, swims in water, and, if washed, the colour is restored. This inflammation may terminate by resolution, or it may pass into some higher degree of inflammation.

When serous inflammation succeeds, the lung is in the same gorged state, but in addition it is loaded with serum, so that on cutting into it a watery fluid mixed with blood streams from it as from a sponge. The lung now no longer crepitates, is enlarged, often takes the impression of the ribs, and does not collapse when the chest is opened.

At a higher degree of inflammation lymph is thrown out, and the lung is now technically said to be in a state of red hepatization, or, as Andral has termed it, red softening. This state has many degrees. In some instances the lymph effused is very large in quantity, mixed with blood, and can be readily separated, or, as it were, *shelled* out of the lung, and in this loose state it is not organized. In the other extreme of this form of inflammation the lymph effused has become organized, and forms an integral part of the lung, which now becomes so solid that, if cut, it represents with much accuracy a portion of the liver or spleen. In this state it contains at the diseased part little or no air, does not crepitate, and sinks in water; it cannot be injected, is of a deep venous colour, while its texture is easily broken down and penetrated by the finger. The lung also is enlarged, and does not collapse when the chest is opened.

A still more severe form of pneumonia is suppurative inflammation, and the pus effused may be either infiltrated or contained in an abscess. Infiltration is by far the most common; and although this form of disease may occur *per se*, yet in the belief of most authors it more generally follows red hepatization. In this latter case the pulmonary tissue, red, dense, compact, and impermeable to air, passes to a grey colour, and hence it is termed grey hepatization. The structure in other respects of either form of hepatization appears to be the same; for if we examine them with a microscope, we find the same granulations, only they are white or grey instead of red. There are instances, however, in which these are wanting, and we observe only a grey smooth surface.

In the grey, as in the red hepatization, the pulmonary tissue is easily torn, and the quantity of pus infiltrated is sometimes so great that, on cutting into the lung, that fluid readily flows from it; at other times the pus will not flow on a simple incision, but exudes by compression.

Although pus is more commonly diffused through the pulmonary parenchyma, yet sometimes it is collected into an abscess. In the infancy of pathology physicians regarded phlegmonous abscess of the lung as a common and ordinary occurrence, but it is extremely rare; and Laënnec, when he published the first edition of his work, had only met with six cases, notwithstanding all his extensive research; and in the practice of every other physician phlegmonous abscess of the lung is equally uncommon. Abscess of the lung, although termed phlegmonous, to distinguish it from tubercular abscess, generally exists without any great intensity of inflammation or other considerable alteration of its tissue.

Pneumonia may also terminate by gangrene, which is also as rare a termination as by abscess. It occasionally arises from excess of inflammation, but more commonly the inflammation which precedes this state is of little intensity, so that it rather approaches to anthrax, or pestilential bubo, and the inflammation around the gangrened portion appears to be the effect rather than the cause of the mortification. The gangrened portion may or may not be circumscribed, and is found in the different states of gangrenous eschar, of deliquescence, of sphacelus, and lastly of simple excavation, the gangrened portion having been detached and escaped.

The frequency with which these different forms of inflammation occur is not yet estimated, but is probably in the inverse order of their intensity, the diffuse inflammation being the most frequent, then the serous, the adhesive, the purulent, and lastly the gangrenous.

Pneumonia may be either single or double,—that is, it may attack one or both lungs at the same time. Thus, out of 210 reported cases, 121 were on the right side, 58 left side, and 25 double, while the seats of 6 were unknown. Of the part of the lung attacked, out of 80 cases of pneumonia 47 consisted of inflammation of the inferior lobe, 30 of the superior lobe, while 11 times the whole lung was inflamed.

Bronchitis may take place without pneumonia, but in many cases pneumonia follows as a consequence. Pneumonia also may take place without bronchitis, but in general bronchitis accompanies it. Pneumonia also may take place without pleuritis, but it generally happens that the pleura is more or less affected.

Much speculation has been entertained with respect to the more particular seat of pneumonia, some contending the inflammation affects the cellular tissue of the lung, and others the air-cells, others both. It is quite certain, however, that the minute bronchial tubes are not affected in slight pneumonia, for in such cases their divided extremities stand out in the midst of the inflamed part like so many white points. When the lung is more acutely inflamed the bronchial tubes are red, and evidently greatly inflamed. It has been stated that chronic pneumonia is supposed by many writers not to exist.

Besides being subject to inflammation, the lung may be hypertrophied. Thus Laënnec observed a great number of cases in which one lung being no longer able to fulfil its functions from effusion of air or fluid into the cavity of the chest, that the healthy lung acquired a volume manifestly greater than normal, its tissue being more dense and compact, so that it did not collapse on opening the chest, and more resembled the lung of a child or of a horse. This hypertrophy may take place in no very long time. Laënnec, for example, found this alteration in a man who, six months before, had suffered from a pleuritic attack, in consequence of which the lung on the diseased side became atrophied, and the chest deformed. This alteration is the result of the law, if one of a double organ becomes atrophied, or incapable of performing its functions, the other becomes the seat of greater nutrition and more active function.

The lung may likewise be atrophied, a condition common to old age, when it becomes of less volume,

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contains less blood, and is of a remarkable lightness. In other cases the atrophy is the result of disease, as after collapse from empyema, when the lung is often little larger than the fist, without any trace either of bronchi, of cells, or of cartilages.

The sole entozoaires which have as yet been met with in the substance of the lung are acephalocysts; and Andral has seen one entire lobe transformed into one vast hydatid cyst. In another case he found a collection of hydatids in the interior of a considerably dilated pulmonary vein. A recent instance of hydatids of the lung is also given in the *Bulletin de l'Académie Royale.* These parasites, however, though common in animals, are happily rare in man. The lung has also been found the seat of steatoma. Thus Sir Astley Cooper stated, that he found the lungs of his late Majesty, George the Fourth, loaded with fat. The substance of the lungs is also occasionally the seat of ossific deposits, and portions of evidently ossified cellular tissue have often been expectorated.

*Pathology of Pleuritis.*—The pleura is the membrane covering the lungs, as well as lining the cavity of the chest, and is liable to all the inflammations incident to other serous membranes, or to the diffuse, the serous, the adhesive, the suppurative, the ulcerative, and to the gangrenous, and these may be either acute or chronic.

The diffuse inflammation begins in the sub-pleural tissue, whose vessels enlarge and admit red blood, and shortly afterwards the red blood penetrates the web of the pleura itself. At first a number of red dots or punctures are seen, which at length are so multiplied as to become confluent and form large patches, which spread till perhaps the whole of the pleura pulmonalis and costalis is one continued inflammation. The membrane is in all cases of a bright red or arterial colour, slightly thickened from interstitial deposit, and easily detached from the now increased lacerability of the subcellular tissue.

If the diffuse inflammation be of any intensity, the secretion from its surface is in general suspended, and the membrane is dry. In this state the inflammation may terminate by resolution, or serum may be poured out, causing *serous inflammation.*

The quantity of serum effused is very various, in some cases hardly exceeding a very few ounces, while in other cases it amounts to many pints, filling that cavity of the chest which is the seat of inflammation. Laënnec is of opinion that the time of effusion after the commencement of the inflammation is often very short, as he has detected ægophony and absence of respiration, as well as of thoracic resonance, an hour after the patient has first felt pain in the side, or "le point de côté." If the effusion be considerable the lung becomes collapsed, contains no air, and therefore no longer crepitates; the vessels are devoid of blood, while the bronchi, even to the large trunks, are evidently contracted; still, if this lung be inflated it enlarges more or less perfectly. Again, should the pleuritic effusion be less in quantity, some fluid appears spread all over the lung; but the greater quantity is always collected at the lowest portions of the chest.

Accompanying either of the previous forms, or else existing *per se*, lymph may be thrown out, and adhesive inflammation be set up. In many cases the lymph thrown out is loose and watery, sometimes only rendering the serum turbid or flocculent; but in other cases it is more solid, and adheres with great tenacity to the opposite membrane, and becomes organized at both surfaces. The organization of these membranes is rapid, and is often effected by the end of 24 to 48 hours. If the patient falls shortly after an attack of acute inflammation, these adhesions are found soft, easily lacerable and extensible, and in this state are perhaps sometimes absorbed. If, however, he survive a longer period, the adhesions are often of great tenacity, are indurated, and with difficulty separated from their attachments. The extent of membrane affected with adhesions is very varied, sometimes limited to a small portion, and sometimes extending over the whole cavity, but their most common seat is generally the anterior lobes, or the portion from the mammæ to the axillæ.

The pleuritic inflammation sometimes terminates in suppuration; and should the pus be in such quantity as to accumulate in the cavity of the chest, the disease is termed *empyema.* Empyema may be true or false: it is said to be true when the pus is secreted by the pleura, and false when it results from the bursting of an abscess of the lung into the cavity of the chest. The quality of the pus in true empyema varies from a genuine laudable pus to a sero-purulent fluid. In quantity also it varies from a few ounces to many quarts, filling the entire cavity of the chest. Under these latter circumstances the side of the chest is dilated, and the intercostal spaces widely separated and bulging.

Effusion of pus may take place into either cavity of the chest, but the left perhaps is the most common; at least three cases have been observed in St. Thomas's to one on the right. The phenomena accompanying empyema of the left side are remarkable; for, besides the lung being found collapsed, not so big as the fist, and often without a trace of bronchi or of bronchial cartilage, the heart is sometimes seen transposed as far over on the left side as it usually is on the right. Under these extraordinary circumstances, if we examine the chests of these patients after death, if paracentesis has not been performed, the heart is found to return to its natural position in proportion as the pus flows, showing that it is rarely fixed in its new situation by adhesions. In other cases, however, in which paracentesis has been performed, and the pus has been drawn off, the heart is found in its place, while the lung, less completely collapsed, is bound down to the upper and lower portion of the chest by long and multiplied adhesions, which entangle large quantities of pus, and are perhaps the cause of the ultimate fall of the patient.

Such are the red or chromatous inflammations of the pleura, but it is also the seat of many achromatous inflammations. Thus large quantities of pus, extensive adhesions, or a great excess of serum has been often found in the chest, and yet the patient has not suffered any pain during life, neither can a red vessel be traced after death. The adhesions which thus form often give rise to many singular phenomena: their tenacity is notorious, the lung constantly tearing without their yielding, while they are sometimes so extensive as to bind that organ throughout all its extent to the ribs, and limit its play to the mere rising and falling of the chest. They also, like all newly-formed abnormal parts, readily run into disease; and hence we often find them the seat of serous or purulent effusions, forming a partial hydrothorax or a partial empyema. The pleura also sometimes becomes the seat of ossific deposits. Laënnec has seen it converted into a fibro-cartilage, Dr. Baillie into a plate of bone; and in the Museum of St. Thomas's

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Hospital there is a specimen of a bony pleura, occupying almost half the chest, and fixing the ribs, so that it is remarkable how life could have been continued with so extensive a disease. Hydatids have also occasionally been found in the cavity of the chest.

*Symptoms of Pneumonitis.*—Pneumonitis is determined to exist by two classes of phenomena, or by the general and physiological symptoms, and also by certain mechanical phenomena arising out of the physical structure of the lungs and of the chest. It will be better first to describe the general and other symptoms, and then the phenomena arising from percussion and auscultation.

*General Symptoms of Bronchitis.* — Bronchitis, of whatever kind, is often preceded with fever, more commonly by symptoms of a common cold; but it also often commences without any previous illness; in whichever way, however, it begins, the hoarse altered voice, the cough, and expectoration, are too palpable to allow us to mistake the nature and existence of the disease. In a very few instances of diffuse inflammation the cough is dry and without expectoration, but far more generally it is accompanied by sputa; the sputa vary greatly according to the different degrees of inflammation, or according as that inflammation is acute or chronic, sthenic or asthenic. In acute cases it is at first a thin mucus streaked with blood, then more opaque, and lastly purulent; in more chronic cases it may be merely a muciform saliva, or a gelatiniform mass, or it may be like the unboiled white of egg, so tenacious that it may be poured from one vessel into another without separating. In other instances it is puriform, varying from a laudable pus to a red or green æruginous putrilage. When purulent it is usually formed into sputa, but in a few cases it is thrown up in large quantities unmixed, as from an abscess. The quantity of matter expectorated also varies greatly; sometimes only a few sputa in the morning, at others half a pint or a pint in the 24 hours, while other patients actually die suffocated from the immense quantity which is suddenly poured out.

The cough is seldom accompanied by any pain in the inflamed membrane, and has many degrees of violence. It may occur in paroxysms, and the sputa be discharged after a violent effort, at night, or in the morning, or at other definite intervals. Again, it may be incessant, harassing the patient at every instant, causing a sense of soreness or constriction of the chest, and sometimes severe pain at the ensiform cartilage, in consequence of the mechanical exertion of coughing.

With respect to the effects of the cough on the constitution, the patient, supposing the disease to be unconnected with any morbid poison or organic affection of the substance of the lung, suffers little in his general health, and would be well if he could get rid of " the cough." In other cases he loses flesh, throwing up every meal from the violence of the cough, while in others he sinks into a state of marasmus simulating phthisis. His pulse is generally natural, although in some cases it is frequent; his bowels also are regular. In bad cases, however, the patient's nights are broken, but he sleeps towards morning while in slighter cases he sleeps through the night but is disturbed in the morning.

The duration of this affection is very various: sometimes it terminates in a few hours, sometimes in a few days, ceasing with the cold that produced it. In other cases its duration is long, and it is with difficulty recovered from, and thus often lays the foundation of phthisis or other formidable disease, which ultimately destroys the patient. In old persons it generally returns every winter, or lasts, with intermissions, the whole year.

*General Symptoms of Pneumonia.*—Pneumonia is generally preceded by some antecedent fever, or by shivering more or less violent, and often by bronchitis. In a few cases, however, it is the primary affection.

The disease being set up, the patient is restless and uneasy; his respiration difficult and hurried, or from 30 to 50 in a minute; his cough frequent, and his expectoration streaked with blood; but notwithstanding this symptom he seldom, unless the pleura is affected, suffers pain; and hence the adage that in pneumonia there is "plusquam periculi quam doloris." His pulse is full and frequent, or from 100 to 120; his countenance livid; his nostrils dilated; his tongue purple, and coated with a white or yellow mucus, while he lies on his back supported by pillows. If the patient recovers, these symptoms are gradually mitigated; but should he fall his tongue becomes brown and typhoid, his pulse more rapid, profuse sweats break out all over his body, and at length his mind wanders, and he dies comatose, or half asphyxiated. There are many instances, however, where the course is widely different, and in which the patient, though evidently distressed by impeded respiration, has yet moments of cheerfulness; gets up; walks about the ward; but dies during the day, seized with a severe paroxysm of dyspnœa or of coughing.

Such are the general symptoms of pneumonia; and, except by their different degrees of intensity, it is difficult to distinguish the different forms of inflammation from each other without the application of the stethescope. The general symptoms of serous pneumonia, however, are the most marked; the uneasiness being greater, the respiration louder and more difficult; the countenance more livid and swollen, the cough more harassing, the expectoration more abundant, and the attempt to lie down impossible. A gangreoous state of the lung is determined by the intolerable fœtor of the breath.

The duration of pneumonia is very various. Laënnec conceives the diffuse inflammation to last seven or eight days—Andral, red hepatization to last 15 to 20 days; while grey hepatization, when an original disease, is supposed to destroy the patient in 24 or 36 hours from the first symptom of attack. More generally, however, taking all its forms, pneumonia terminates between the seventh and the twentieth day.

*General Symptoms of Pleuritis.*—Pleurisy, like other inflammations of the lungs, may be acute or chronic. The acute form of this disease may be preceded by fever, but often no such antecedent is present. Its local symptoms, however, in most cases, are strongly marked; the patient suffering with severe continued *pain* in the affected side, which is greatly exasperated by coughing, or other forced inspiration, so that the chest can only be half filled with air. The seat of the pain, however extensive the inflammation, is generally limited to one point, termed the " point de côté," and this point is generally about the centre of the mamma, or just below that part. The tongue is commonly white, but the pulse varies perhaps according to the form of the inflammation and its intensity; or, if the disease be limited to an

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effusion of lymph or serum, the pulse is seldom more than 90 to 110; and either form of pleuritis is also generally accompanied by a short troublesome cough, and some expectoration. The patient likewise is for the most part restless, and lies on the affected side. After effusion of serum has taken place, the pain is much mitigated; but if it be in any quantity the lung is compressed, which increases the general uneasiness, as well as the oppression of the breathing, and the patient, instead of lying on his side, now lies on his back, or else sits propped up in bed. If he recovers, the fluid effused is absorbed, with greater or less rapidity, and his amendment is proportionably retarded or accelerated. In fatal cases, although the lung may for a time become accustomed to the altered state of things in the chest, yet fresh effusions occur, and shortly terminate the life of the patient.

Again, if the inflammation is about to terminate by effusion of pus, the pulse is extremely small and frequent, or from 120 to 150, while the restlessness and anxiety of the patient is greatly increased. It is strange, however, that there are cases of empyema, in which the patient suffers little pain, or any more marked symptom than usually awaits the last stages of phthisis. In some instances he is for a time even capable of walking about the ward. Supposing, however, the empyema to have formed, any acute pain the patient may have suffered subsides, but the anxiety of the patient is increased, and his state of collapse shows his imminent danger. On the contrary, if the constitution be less affected, the symptoms vary according to the side of the chest which is the seat of the empyema. If it be on the left side, for example, the heart is often transposed, and felt beating as far over on the right side as it usually does on the left, and the pulse is small and frequent. If we now bare the chest of the patient, we find the affected side enlarged, sometimes œdematous, with projecting intercostal spaces. As the lung is now greatly compressed, no respiratory action is seen on that side, which is entirely at rest. If an operation be now performed, the heart is restored to its place as the pus flows; but as the lung for the most part only imperfectly expands, the affected side, even in the most favourable cases, contracts, and the spinal column, pressed upon by an unequal weight, acquires a lateral curvature; the shoulder sinks, and the patient is greatly and permanently deformed.

The duration of acute pleurisy is very various, sometimes terminating in a few hours, sometimes in a week or ten days, while Laënnec has met with cases in which many months have elapsed before the pleuritic effusion has been absorbed, and the patient restored to health.

Such is a short account of the physiological symptoms which mark pneumonitis; and it will now be necessary to add those physical symptoms which render the seat of the disease, as well as its nature, more definite and precise.

*Physical Symptoms of Pneumonitis.*—On striking the chest of a person in health, it returns, like a half-filled cask, a certain hollow sound, demonstrating it to be partly filled with air. Also, if we place the ear to the chest, we hear certain sounds on inspiration and on expiration, which are termed the respiratory bruit or sound. In disease these natural sounds are altered, the sound on percussion being rendered duller or clearer than natural, while the bronchial respiration undergoes still more remarkable alterations; and these modifications frequently enable us to determine the nature and seat of the disease.

*Physical Symptoms of Bronchitis.*—The natural and healthy respiratory bruit of an adult has been compared to the sweet sleep of a healthy child; but in bronchitis this sound is changed, and varies in different cases, from a tolerably sharp sound, which, when multiplied from a number of bronchi being similarly diseased, resembles the chirping of a nest of young birds, to the bass note of the violoncello, and consequently embraces a musical scale of considerable compass; the principal and more marked division of which, Laënnec has termed "râle sonore ou ronflement," "râle siffilant sec ou sifflement, râle tourterelle, and râle musicale." The cause of the higher notes has been supposed to be owing to a thickening of the mucous membrane at the orifices of the various bronchial tubes, so that the natural embouchure is narrowed, and a musical wind instrument thus formed. To those who have observed in the dead body a swollen state of the bronchial membrane, this explanation may seem satisfactory; but to those who deny the existence of any such phenomenon, it seems more easy to explain this morbid sound by different degrees of contraction of the circular and longitudinal fibres of the bronchi, in the same manner as we observe contraction of the muscular fibres of the œsophagus, or of the small intestines, causing stricture. The general law, also, that the orifices of parts are more often diseased than their more central portions, explains why this contraction should take place principally at the orifices of the bronchi, and hence the shrill piping or chirping sounds so often heard.

Laënnec has left the grave sounds entirely unexplained; and these are caused probably by an opposite state of parts, or by a relaxation both of the circular as well as of the longitudinal fibres, so that the bronchial tube is more open, elongated, and inflexible; and hence its vibrations are consequently longer, and the note more grave.

Besides the alteration of tone in bronchitis, its quality is also often affected by the presence of liquid matters within the cavity of the bronchi, and hence we have it interrupted and modified by the air passing through bubbles of mucus; and as the size of these bubbles and their viscidity vary, so the sound varies; and hence a scale has been established by Laënnec, whose extremes are the "râle muqueux," and the râle tracheal; the former representing the bursting of small slightly viscid bubbles; the latter larger ones of greater tenacity, and like those formed in gurgling. Sometimes this mucus, instead of being fluid, hardens so as occasionally to adhere and play as a valve, giving rise to a clicking noise, which has been termed by Laënnec, "bruit de soupape." These are the various morbid sounds heard in bronchitis; and the danger of this disease is denoted by the quantity of fluid effused, and by the gravity of the sound. The sharp chirping sound, as it denotes contraction, and consequently power, is less to be feared than the graver and deeper notes caused by relaxation, and consequently *loss* of power, and which shows that the air circulates with great difficulty in the bronchial cells. There is also another râle, which perhaps should be mentioned in connexion with bronchitis, or the "râle crepitant à grosses bulles ou craquement," which Laënnec compares to the blowing of air into a dried bladder, and is the pathognomic sign of rupture of the air-cells, and

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of penetration of air into the cellular tissue of the lung itself. In addition to the alteration of the tone in bronchitis, some indication may be drawn, according as the times of expiration are prolonged. In health the times of inspiration are much longer than those of expiration; but, in disease, these times are often equal, and, in some instances, that of expiration is longer than that of inspiration. This change is also a proof of severe bronchial inflammation.

Percussion generally returns a healthy sound in bronchitis. It may however happen, when the lung is acting irregularly, that a number of counter-currents may cause it to return a dull sound, like a glass of champagne while the wine is still effervescing.

*The Physical Symptoms of Pneumonia* vary in proportion to the intensity of the inflammation, and the consequences it produces. Diffuse inflammation is determined by a râle termed "crepitant." This bruit evidently takes place in the pulmonary tissue, and is compared by Laënnec to the crackling of salt thrown upon the fire, or to air blown into a dried bladder, or to the crepitation of the healthy lung when pressed between the fingers. The cause of this râle is variously interpreted, some pathologists attributing it to the dryness which sometimes accompanies diffuse inflammation, while others attribute it to bubbles of air breaking in a fluid of something of greater density than water, and secreted in the cells of the inflamed part; crepitation, however, is rarely distinctly heard.

If the pneumonia assumes the character of serous inflammation, it is quite singular how loud a mucous rattle is heard; it resembles a loud roaring rather than crepitation, and is supposed to be caused by bubbles of air breaking through a mass of slightly viscid fluid. This phenomenon is one of the most remarkable connected with disease of the lung. In both the preceding forms of inflammation the chest on percussion returns in every part a clear sound, the air still penetrating every part of the lung. If a dull sound is returned, it is on account of counter-currents.

Should the pneumonia proceed, and red or grey hepatization take place, the lung is solidified, and the bronchial tubes being either temporarily or permanently obliterated, no air penetrates the diseased portion, whence it follows that not only is the respiratory bruit lost, but also that the chest at this part will return a dull sound on percussion. These are the conclusions from theory; but it is seldom, unless the disease be very extensive, that these conditions can be satisfactorily established; for the noise of the surrounding bronchitis, and the supplemental bruit of other portions of the lung almost entirely mask the absence of respiration in the affected portion. Again, if the hepatization be central, the air in the more superficial portions of the lung often prevents a dull sound from being returned on percussion. In this difficulty, however, there is one symptom which greatly assists our diagnosis, or *bronchophony*. When the lung is hepatized or solidified, it has necessarily become a better conductor of sound, so that the voice, instead of being destroyed in the chest, as in the healthy lung, is now conducted downwards. In this altered state of parts, if the stethescope is applied to the chest, and the patient directed to talk, his voice is distinctly heard in the chest, and at the end of the stethescope, but without passing through it. This phenomenon is termed bronchophony.

Pneumonia, it has been stated, sometimes, though rarely, terminates in abscess. The physical symptoms previously to the bursting of the abscess are those of hepatization; but supposing the abscess to have burst into the bronchial tubes, the pus of course escapes, and a cavity filled with air is left communicating with the bronchial tubes, and this new state of parts gives rise to a new series of phenomena. The air, for instance, having penetrated into the cavity, the part which returned a dull sound, while the abscess was yet unbroken, will now return a sharper and clearer sound on percussion than natural, denoting a larger admission of air than even in health. Again, on auscultating the chest, we find some changes have taken place both in respiration and in the transmission of the voice. If the cavity, for example, be large and the opening small, the natural respiratory bruit at that part will be superseded by a sound resembling a person blowing into a decanter, and from this circumstance termed, by Laënnec, "râle amphorique," or "bottle sound."



Again, if the cavity be large and its walls dense, and the abscess still contains some pus, we hear a sound as if a drop of water had fallen into a pool; and this sound is so sharp and metallic, that it has received from Laënnec the term "tintement metallique," or metallic tinkling. It is usually supposed that this sound is produced by a globule of pus dropping from above into the fluid below; but some pathologists are inclined to believe that it is owing to the bursting of a bubble of air, mixed with the pus of the abscess. Another phenomenon is, if the abscess be large, and contain some pus, that, on the patient coughing, we actually hear the "wabbling" of the pus against the walls of the abscess. The last of these singular circumstances developed by auscultation is, if a large abscess be situated at the superficies of the lung, and the walls of that abscess be thin and not adherent, the auscultator has the disagreeable sensation of somebody sucking air out of his ear at the end of the stethescope, and this has been termed by Laënnec "souffle voilé." This striking symptom enables us to determine not only that there is an abscess, but that abscess is superficial, and its external wall not adherent; so we may affirm, if other symptoms indicate the presence of an abscess, and this symptom be absent, that the abscess must be deep-seated, or, if superficial, must be adherent.

The next remarkable circumstance revealed by auscultation in the event of an abscess is *pectoriloquy*, which is, that on the stethescope being applied to the chest, and the patient desired to talk, we hear his voice as if he were directly speaking at the end of the stethescope, the sound passing directly to the ear as through an ear-trumpet. This phenomenon results from the same cause as that which makes the aneurismal sac pulsate stronger than the healthy artery itself; or supposing the capacity of an artery to be as 6, and the aneurismal sac as 12, and the moving force as 3, the artery will pulsate with a force equal only to 18, while the sac will pulsate with a force equal to 36. In like manner, the vibration of air will be so much stronger in the empty cavity of an abscess as the cavity itself is larger than the bronchial tube; and hence this greater vibration of air is powerful enough to occasion a distinct vibration of the walls of the stethescope, and consequently a direct transmission of the voice to the ear.

Pectoriloquy, however, does not take place in all cases of abscess of the lung, but may be considered the exception rather than the rule of this disease. The

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cause of this is, that many conditions are necessary to its existence; first, that the lung must be condensed so as to have some conducting power, or else the voice will be destroyed, as in health, before it reaches the aperture communicating with the abscess. Again, it is necessary that the patient should have a sufficient quantity of voice to produce strong vibration; but this is often wanting. Another condition is, that the bronchial opening of the abscess be not too large, for in that case the vibrating force is diminished, and instead of representing a power of three to a square inch, it will now perhaps be reduced to a power of one to a square inch. It is likewise injurious to the effect that there be more than one opening into the abscess; for in that case not only is the vibrating force diminished, but the counter-currents destroy all vibration, as has been instanced in an effervescing glass of champagne. It is plain also that the walls of the abscess must have a certain density, or else their flaccidity will act like a damper, and destroy all vibration. Many conditions, therefore, are necessary to pectoriloquy; and we cannot feel surprised that one or more may be wanting, and the phenomenon in question frequently absent.

Besides an opening into the bronchial tube, the abscess may at the same time open into the cavity of the chest, producing what has been termed a triple opening, and this new pathological state gives rise to a tintement métallique of the chest infinitely more powerful than that caused by a pulmonary abscess. Indeed the intensity and sharpness of the sound quite equals that returned by a copper vessel when struck with a slight force; for the intercostal muscles, irritated by the air and pus in the pleural cavity, brace the walls of the chest like a drum, so that they become an excellent conductor of sound. The immediate cause of the sound is supposed to be exactly the same as when it results from an abscess, either a drop of fluid falling into the pus below, or else the extrication of a bubble of air from the gravitated pus. The chest in these cases always returns a remarkably clear sound on percussion.

In *Pleuritis*, auscultation and percussion are equally valuable in determining the amount of effusion, and sometimes the nature of the effusion. If serum or pus be effused to the amount of a pint, the lung is displaced to that extent; and consequently the lower portion of the chest, when struck, returns a dull sound, which extends as high as the level of the fluid. If we now auscultate the patient, the respiration is also lost below the level of the fluid. Besides these results, the voice gives very striking indications of the lung becoming condensed from the presence of the fluids; for we very constantly have bronchophony, and occasionally ægophony. In the latter case the voice, instead of being articulated, as in bronchophony, is broken, vibratory, and inarticulate, so that it has been compared to the bleating of a goat, or to the nasal vibratory notes of Punch, and hence it has been termed by Laënnec *ægophony*. This symptom has been supposed to be caused by oscillation of the fluids in the chest incessantly altering the diameter of the bronchial tubes of the compressed lung.

When the effusion is so considerable as to form empyema, and the cavity of the chest be only partly filled, we sometimes have, as in a case now in St. Thomas's Hospital, a tintement métallique. It has been thought that a triple opening was in all cases necessary for the production of this sound, but in the patient alluded to there was no reason whatever to suspect abscess of the lung. In a similar case that died some years ago in the same hospital, although the tintement métallique was most marked and complete, yet on examining the patient no air passed from the lung into the chest, even when the lung was inflated after the cavity of the chest had been filled with water, neither could any trace of an abscess or of an ulcer of the lung be found. The presence of air is perhaps necessary to this phenomenon, but this may be generated by putrefaction, or be extricated by secretion, and consequently a communication with the external air is not essential.

If the chest be completely filled in empyema, the respiratory sound is altogether wanting; so is ægophony and bronchophony, and the containing cavity returns a dull sound at whatever part percussed. Under these circumstances, and especially if the heart be transposed, the patient should be undressed, when the affected side will be seen entirely motionless, rounded, and distended; and when these signs are present there can be no doubt of the disease being either empyema or hydrothorax.

Besides pus being effused into the chest, lymph may be thrown out in a more or less solid state; and this morbid result gives a rubbing sound, as though the play of the lung was impeded by a rough uneven surface. Such are the physical symptoms accompanying pneumonitis.

*Diagnosis.*—It is hardly possible to confound bronchitis with any other disease; but there is often much difficulty in assigning its cause, and distinguishing it from phthisis. The quietness of the pulse, however, the absence of great emaciation, and the clear resonance returned on striking the chest, are the best diagnostic symptoms. Pneumonia is distinguished from phthisis by the previous good health of the patient, and by the more acute nature of the disease; and, in some degree, by a difference of its seat, the lower lobes being more particularly affected in inflammation, the upper lobes in phthisis. The two diseases, however, it should be remembered, are often combined. Pleurisy is distinguished from the other forms of pneumonitis by pain, and by the very distinct evidence of effusion afforded by auscultation and percussion.

*Prognosis.*—Bronchitis is not often fatal in young persons, unless it is connected with phthisis. In the aged, however, it is often combined with disease of the heart or other affection, and is often fatal. Chomel says, he lost 40 cases out of 123 in one instance, and 38 out of 96 cases in another. It is supposed that one in three die when attacked with pneumonia or pleuro-pneumonia. Louis lost 28 out of 78; but this varies greatly in different years. A large proportion of those attacked by pleurisy recover, but the numbers are not determined. Andral observes, that pneumonia of the superior lobe is more grave than pneumonia of the inferior lobe, and this arises from two causes; first, in the young the superior lobe is often previously diseased, while, according to Louis, pneumonia of the superior lobe is one of the contingencies of old age.

*Treatment.*—The treatment of all the forms of pneumonitis varies according as the disease is acute or chronic, and according as it depends on simple inflammation, or on a morbid poison, conditions which it is often extremely difficult, sometimes impossible, to determine, and which consequently greatly embarrass our practice.



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Abundant experience has shown that large bleeding in acute *bronchitis* uniformly weakens the patient without greatly influencing the disease. Neither has medicine any very marked effects in the cure of this disease; for although some persons rapidly get well under a given treatment, yet many other similar cases, under exactly the same treatment, will run on for weeks, and perhaps for months, without any amendment. In the most acute cases of bronchitis, however, some blood should be taken from the chest either by cupping or leeches, and in general 10 to 12 ounces are sufficient; and in acute cases the quantity of fibrine of the blood is increased from 3 to 6, 7 and 9. After this a blister should be applied to the chest, and, on its being removed, a large linseed poultice should be placed over the blistered part, and continued for many hours, which will not only keep the ulcerated surface open, but gratefully foment and relieve the patient. In the medical treatment, some opiate after the bleeding is necessary to allay the cough; and any preparation of opium, as extracti opii or morphine, or else the syrup of poppies, or of any other narcotic, as of hyoscyamus, or of conii, should be given in moderate doses, every four or every six hours. It is usual also to add to each dose a grain of ipecacuanha, or $\frac{1}{4}$ of a grain of antimonii c. potassio tartarizati, or else some neutral salt, as the liquor. ammoniæ acetatis, ℥ ſs., or the magnesiæ sulphatis ℥ j., according to the state of the bowels. In a few instances, small doses of mercury are beneficial.

In chronic cases of bronchitis the blood is found to be natural in its proportions. After blistering, and perhaps poulticing the chest, the treatment is in general more tonic; as the mist. cascarillæ ter die, or the infus. rosæ c. oxymellis scillæ ʒ ſs. c. tinct. hyoscyami ♏ xv. ter die. Ten grains of benzoic acid out of mist. amygdalæ is another useful remedy, and the mist. ammoniaci or the mist. assafœtidæ are often beneficially employed. If the cough be greatly troublesome syr. papaveris ʒ j., or confectio rosæ may be given almost *ad libitum*.

The treatment of *Pneumonia* is one of the most discordant points of medicine. Most practitioners, finding the blood well buffed and the fibrine increased to five, six, seven, eight, and nine parts, instead of three, treat it by large bleedings; while Laënnec and Louis seem to deduce from their experience that large bleedings are by no means an eminently successful practice, and that in some cases they are absolutely injurious; and the same difference of opinion is held with respect to large doses of antimonii c. potassio tartarizati. These discrepancies are painful, and can only be explained by the circumstance that pneumonia perhaps more frequently depends on the action of a morbid poison than is generally believed.

The ancients bled in pneumonia, and sometimes to deliquium, and Galen appears to have adopted this practice. This was also the practice of Sydenham; and Laënnec says it was common in France at the beginning of the last century to take 24, 30, and 36 ounces of blood at one bleeding. This practice is, within certain limits, followed throughout Europe at the present day, and there can be no question of its propriety in some cases of simple inflammatory pneumonia; but it appears to be a great error to make excessive bleeding the basis of the cure in all cases.

In epidemic pneumonia, says Laënnec, it is hardly possible to bleed the patient without rendering him worse. In 1814 pneumonia was very common among the conscripts, yet there were few indications for bleeding, and those that were bled were rendered so much worse that, says Laënnec, "Je n'osai pas la réitérer." It is probable under similar circumstances that Louis bled, and was equally dissatisfied with the result he obtained. It will be plain, then, that with respect to bleeding, much must be left to the discretion of the practitioner. That there are cases in which the patient can only be saved by energetic bleedings everybody must admit, while, on the contrary, when pneumonia is epidemic the quantity of blood drawn must be greatly limited and the case well watched. The ancients held that bleeding should not be practised after the fifth day, as it prevented *concoction*. The cases of Louis appear to establish the propriety of early bleeding as a general rule; for he says those bled in the four first days of the affection are cured four or five days sooner than those who are bled later in the disease.

It is rare that the cure of pneumonia is left entirely to the influence of bleeding. Rivière used to treat pneumonia by giving the patient an emetic every day or every other day, a practice which has at all times had many partisans. Senac being told by his son that he bled too little and gave too many emetics in pneumonia, abandoned his own plan, but with so little success, that he exclaimed one day, "You have made me a worse physician than I was before." We owe to Rasori the introduction, in modern times, of large doses of emetic-tartar in the treatment of pneumonia. Laënnec was so dissatisfied with his own results of bleeding that he adopted it, and thus describes his practice:—

"As soon as the disease is determined, if the patient be in a state to bear bleeding, I take from eight to sixteen ounces of blood from the arm. I do this as momentarily arresting the inflammation, and thus giving the tartar-emetic time to act, and I rarely repeat this bleeding. Immediately after this bleeding I give the first dose of tartar-emetic, or a grain in two ounces and a half of orange-flower water, and I repeat this dose every two hours for six times; I then allow the patient to repose for six or seven hours. If, however, the disease be severe and the oppression great, I continue it every two hours till the symptoms are mitigated, increasing the dose from one to two grains, or even to two grains and a half. The immediate effects of this practice were, that the larger number of patients vomited two or three times, and had five or six stools on the first day, but afterwards the evacuations were trifling, and when tolerance was established they often required purgative medicines, while many bore these large doses almost without vomiting or experiencing any purgative effect. The result was, that Laënnec cured 27 cases out of 28 in 1824 and in 1826.

The great success obtained by Laënnec appears, however, to have been of short continuance, for M. Lagarde has published an account of 16 cases treated by Laënnec by this method, of whom 5 died, while Lecoultreux has given a list of 30 cases, likewise treated by Laënnec, and of whom 12 died. Neither have other physicians in other years been more fortunate, for Louis treated 15 cases according to this method, and 6 died; Chomel, 140 cases, and 40 died; while Gueneau de Mussy treated 90 cases, of whom 38 died. Andral has likewise treated a considerable number of cases of pneumonia by tartar-emetic, in quantities varying from 6 to 32 grains in the 24 hours; and he adds, I

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have seen but two unpleasant or grave accidents result from these large doses. Sometimes the patient has not been at all affected, has neither had nausea, vomiting, or diarrhœa, or abdominal pains; at others he has suffered from nausea and distressing vomiting, effects which have subsided on omitting the medicine. Tartar-emetic, he adds, may therefore be given with impunity. But is it useful? I have not, he adds, seen pneumonia ameliorated by large doses of this medicine; for neither has it appeared to do good when borne by the stomach, nor when it has excited distressing nausea and vomiting. Bouillaud rejects it altogether, and prefers large bleedings, by which means, he says, he recovered 90 patients, and lost but 12.

Having thus stated the practice of these eminent physicians, it only remains to add our own opinions of the best mode of treating pneumonia. The quantity of blood drawn varies greatly according to the season; in London, however, it is seldom necessary to take more than from 16 to 30 ounces of blood, and these, if the symptoms demand it, should be drawn as early in the disease as possible. It is seldom right, however, to trust to bleeding alone; and it has appeared to us that a combination of antimony and calomel has saved a much larger number of cases than antimony alone; a quarter of a grain, then, to a grain of antimonii c. potassio tartarizati, combined with one grain of calomel, given every four or every six hours, according to the severity of the disease, is by far the best treatment. In cases of simple serous pneumonia even simpler remedies are sufficient; and two grains of ipecacuanha given 6^tis vel 4^tis horis have frequently been followed by the recovery of the patient.

With respect to counter-irritation, the greater number of physicians, says Laënnec, regard blisters as next to bleeding in combating pneumonia; but I, he adds, rarely employ them, for they seldom appeared to cure the patient, while they too often seemed to augment the fever and the partial congestion; while Louis says blisters have no evident action in the cure of pneumonia.

The diet in pneomonia should be slops; the chamber kept warm, but not hot.

*Treatment of Pleuritis.*—In acute pleurisy the best practitioners of all times and of all countries have taken blood from the arm; and if, says Laënnec, after one or two bleedings the pain in the side and fever have not abated, blood should be taken from the side by leeches or by cupping. Cupping, he adds, is however much better than leeches, for it is more prompt, less painful, and we can take the exact quantity of blood we wish for. Leeches, on the contrary, are long in drawing and uncertain in the quantity they take, sometimes filling rapidly, and then again hardly biting; while in other instances the bites will cease to bleed as soon as the leech is off, while in others again they continue bleeding for 24 hours. The practitioner should remember that effusion often takes place after bleeding in consequence of a subsidence of the inflammation, so that the breathing is often more oppressed and the symptoms for a time aggravated, although the patient is in reality better. The lung, however, soon gets accustomed to this new state of things; and the fluid in a few hours beginning to be absorbed, the symptoms are now generally ameliorated.

Tartar-emetic, says Laënnec, is in general well supported in pleurisy, and contributes powerfully to assuage the inflammatory orgasm; but nevertheless, when the pain in the side and fever have ceased, it loses all further power over the disease, at least does not appear to promote the removal of the fluid effused, so that he always abandoned its use as soon as the acute symptoms had passed away.

With respect to the application of blisters, Laënnec objects to their use until the acute stage is passed; but when the pain has ceased for some days, and absorption of the fluid proceeds slowly, and the disease promises to become chronic, he now applies a blister. Louis says we may neglect them without any sensible inconvenience.

Such is the treatment recommended by Laënnec. There can be no question, however, after bleeding the patient from 10 to 20 ounces, according to the severity of the case, that calomel is a more powerful remedy than tartar-emetic, and that five grains of calomel, once, twice, or more times a day, often stops the inflammation, saves a great deal of blood, and often, indeed, the patient's life; and supposing effusion of serum to have taken place, it is the best absorbent we possess, especially when combined with the bitartrate of potash, neutral salts, or other diuretic.

Should empyema have taken place, and pus be effused to such an amount as to make it impossible to hope for its removal by absorption, the operation of paracentesis of the chest ought to be performed. Laënnec says the space between the fifth and sixth rib, counting from above downwards, should be selected,—being the most depending part of the chest when the patient lies on his left side, which must be considered his more usual position in this disease. When the chest is punctured the pus should be entirely evacuated; at least no advantage results to the patient from any portion of it being retained, for even when the heart is displaced no adhesions have yet been observed so strong as to prevent it resuming its place as the pus flows. After the pus has been drawn off, the great difficulties of the further treatment arise out of partial adhesions of the lungs preventing the escape of the matter, and consequently the closing of the wound. It may be questionable whether a probe ought not to be introduced to break down the attaching parts, and also whether injections of tepid water might not be used advantageously to bring away the putrid or thickened matters contained within the chest.

The diet of the patient while labouring under acute pleurisy should be slops; after, however, the operation of paracentesis of the chest he should have a liberal support of wine as well as of animal food.

### Of Inflammation and other simple Organic Diseases of the Heart.

The anatomy as well as the pathology of the heart and large blood-vessels begins with Harvey; but the subject can hardly be said to have taken a scientific form till the beginning of the present century, when the work of Corvisart appeared, followed by that of Burns in England, of Testa in Italy, of Kreysig in Germany, and of Bertin and more especially that of Laënnec in France; and a large school has been since formed in Europe by the labours of these eminent pathologists.

The inflammations of the heart embrace Pericarditis, Carditis, and Endocarditis. 3788 cases are reported to have died of these diseases in England and Wales in the year 1839, a number evidently infinitely below the



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truth, and shows how imperfectly this class of disease is yet studied and known. The knowledge, indeed, of the profession generally respecting carditis and of pericarditis is too unsure, and our description of them consequently too desultory to allow us to treat of the inflammation of the heart in the same concise manner as we have done those of the lung, and compels us to describe each form of carditis under a separate head.

### Of Pericarditis.

Pericarditis is an inflammation of the serous membrane containing and covering the heart *externally*. The total number of persons reported to have died of this disease in 1839 was 135, so that this affection is extremely rare.

*Remote Causes.*—The pericardium is acted upon by a few morbid poisons, as the paludal poison, perhaps the poison of the plague, of the small-pox, of scarlet fever, and of scurvy. The most common cause of pericarditis is the rheumatic or gouty virus; and the diseases of the pericardium arising from those causes will be treated of under the head of Rheumatism. The other causes are extremely undetermined, and perhaps are to be referred to general causes acting upon a peculiar idiosyncrasy; thus pericarditis is often connected with albuminous urine dropsy. In other cases it has appeared connected with powerful moral emotions; one lad died of this disease after receiving a good starting, but he might have been ill before.

*Predisposing Causes.*—All ages are perhaps liable to pericarditis; but it is scarcely known in infancy, and is only occasionally seen as a primary disease in children above six years of age. When it arises from albuminous urine dropsy, rheumatism, or the paludal poison, it is most common between 20 and 40. Men appear to suffer more than women, and nearly in the ratio of three to two.

*Pathology.*—The pericardium, like all other serous membranes, is liable to the diffuse, the serous, the adhesive, and to the purulent inflammations. These different degrees of inflammation may exist *per se*, but it sometimes happens that they all co-exist in different parts of this membrane at the same time. They may be acute or chronic.

If the patient falls from acute diffuse pericarditis, the inflamed portion is of a bright rose-colour. This redness is in the first instance caused by the increased vascularity of the subjacent cellular tissue; but as the disease advances red blood penetrates the serous membrane, first punctuating it with a number of dots, which become confluent, and form patches that extend till perhaps the whole membrane is one bright scarlet. Besides being red, the membrane is thickened, first from interstitial deposit, and then from incorporation with the sub-serous tissue; and it is now opaque, white, thickened, and readily detached from the heart.

The diffuse inflammation may terminate by resolution; but more commonly it passes into the serous inflammation, the quantity of serum effused varying from a few ounces to a few pints. Louis has given one case in which it amounted to four pounds, and Corvisart another in which the quantity was still more considerable.

The adhesive inflammation often co-exists with the preceding inflammation, and lymph is now thrown out, and generally in much greater quantity than from any other serous membrane. The lymph thus extravasated may be only in such quantity as to render the serum turbid, or else so extremely loose in texture as to float in it; more commonly, however, it is disposed as a membrane, often covering both surfaces of the pericardium, and especially that covering the heart, and often amounts from two to many lines in thickness. This mass, when considerable, presents a remarkably irregular appearance, and which has been compared to the stomach of a calf, to a portion of a honey-comb, or to two pieces of marble united by grease and forcibly separated. If the patient falls in the acute stage this membrane is found only slightly coherent, and very rarely exhibits any trace of organization.

The highest degree of acute inflammation is when pus is effused, which is generally of a laudable healthy character, though sometimes of a greenish hue. The quantity effused is very various, sometimes only a few ounces, but at others so abundant as to fill the pericardium.

In the chronic forms of the disease all the above morbid states may be observed; but when lymph has been effused it is now commonly found organized, so that the pericardium is often partially or universally adherent all over the heart. In some instances the lymph effused, instead of forming adhesions, becomes converted into cartilaginous and even osseous patches, which are readily detached from the surface of the heart by the scalpel; and in a few rare instances the connecting cellular tissue of the pericardium is so extensively ossified that the muscular walls of the heart have been partially or generally converted into one unyielding mass of bone.

The acute forms of pericarditis sometimes involve the muscular walls of the heart, so that on cutting through them the muscles are seen for a greater or less depth of a deeper colour than usual, and their texture is also impaired, the finger readily passing through them. In chronic inflammation, on the contrary, their colour is sometimes lighter than usual, and their texture firmer.

With respect to the relative frequency of the different forms of inflammation, Louis states he found the fluid effused altogether serous in nine cases, sero-sanguinolent in five, sero-purulent in 15 cases, and pure pus in seven cases; while false membrane or lymph was effused in greater or less quantity in nearly all the cases.

*General Symptoms.*—The symptoms of pericarditis vary, according to most authors, as the disease is the result of rheumatic or of simple inflammation; the symptoms in the former case being extremely well marked, while in the latter they are exceedingly obscure. They are both physiological and physical.

When pericarditis is the result of rheumatism, its most marked characteristic is pain more or less severe in the præcordial region; and from this point it radiates over the whole of the sternum, sometimes extending to the brachial plexus and down the left arm. This pain is accompanied by a sensation of the whole chest being constricted, and by an incapacity to take a long breath, or to cough. From these causes the patient is restless and anxious, his pulse varying from 90 to 110, full and strong, but often intermittent or otherwise irregular; and this state of things having lasted from three or four days to a week, the patient often dies suddenly, with or without his mind having previously wandered.

When acute pericarditis is the result of simple inflammation, the patient suffers no pain, and the symptoms are often most obscure, general as well as physical. Even when the disease is most unmixed, it has been mistaken for a common fever, for pleurisy, and even for

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uteritis. Its abrupt attack, its rapid course, the absence of local pain, and its sudden termination, hardly allow time to fix the seat of the disease. A few instances will best exemplify these assertions.

A sailor boy, who had a few days before received a good starting, was admitted into St. Bartholomew's Hospital. He made no complaint of pain, and he was supposed to labour under typhus fever. During the 36 hours he lived, he was many times sane and insane, and at one time he rushed to the window with an intention of throwing himself out, and then again sunk so low that wine was given to support him. His pulse was at one period rapid, as in the last stage of typhus, and then subsided to 90 or 100. He died, and the only disease was inflammation of the pericardium; lymph, pus, and serum being effused into its cavity.

A lady, says Mr. Burns, after a slight bowel complaint, miscarried. This was followed by vomiting, and the next day she complained of wandering pains on the right side of the chest. Two days afterwards she complained of headache, as well as of most excruciating pain of the pelvis, and the lochial discharge was almost entirely suppressed; she became delirious and died. On examination the uterus was found healthy, the lung of the right side where the pain was first felt was tuberculated, while the pericardium contained a quantity of flaky fluid resembling pus. Rostan thinks the symptoms of acute pericarditis, when not caused by rheumatism, are so obscure that its existence is only to be determined "per exclusionem," or by first determining what the disease is not, we may at length infer that it can be nothing else than pericarditis.

With respect to chronic pericarditis, we are in many instances at a loss to know what symptoms mark its commencement or attend its course. Laënnec says, he has frequently found the pericardium full of pus from chronic inflammation, without any symptom leading him to believe that any such disease existed. When the two pericardia adhere, the symptoms are also equally obscure. In most cases, if the disease be partial, little inconvenience is felt; and even when the adhesions are universal, the patient, though perhaps suffering from occasional palpitation and dyspnœa, yet more commonly falls from some remote disease, as dropsy or affection of the lung. In old adherent pericarditis it is generally supposed that the irritation caused by this morbid state of parts must produce a great flow of blood to the heart, and consequently that it must be enlarged and hypertrophied. It is doubtful, however, whether the fact corresponds with the theory, for many cases have been observed in which, when thus affected, the heart has been diminished in size and its cavities contracted.

The duration of acute pericarditis is from two or three days to two or three weeks. Chronic pericarditis may last many months, and often perhaps many years.

*Physical Symptoms.*—In the difficulty which exists in ascertaining the physiological characteristics of pericarditis, the mechanical functions of the heart afford some physical symptoms which are most useful in determining the existence of this disease as well as others of this organ. The intermittent action of the heart, for example, causes vibrations in its walls which give rise to two natural sounds, termed its bruits. These bruits are best heard when the heart beats about 60; when, however, its pulsations are more than 100, the sounds run more or less one into the other, and to most ears are now confounded. One of these sounds is short and clear, and is termed the *auricular* sound; the other is longer and duller, and is termed the *ventricular* sound. The cause of these sounds has been much debated by pathologists, some attributing them to the action of the valves, others to an active state of the muscles of the heart, both when it contracts and when it dilates, and others again to the circumstance of the blood passing from a larger into a smaller cavity, while Majendie conceives them to arise from the impulse of the heart against the ribs. It seems probable, however, that the causes of the heart's sounds must be multiplex; and as the rush of the water, the vibration of the cylinder, and the clicking of the sucker are united in the sound of pumping, so the rush of blood, the vibration of the heart's walls, and the play of the valves must all be concerned in the production of the sounds of the heart. Still, on whatever cause these sounds depend, they are liable to be much altered, and in 49 cases out of 50 these alterations denote a diseased state of the valves. Again, the heart knocks against the ribs, or has impulse; and this *impulsion*, when greater or less than natural, determines the walls of the heart to have an increased or diminished thickness. The impulsion also may be accompanied by a rubbing sound, termed "bruit de frottement;" and this is supposed to denote an effusion of lymph. Another condition of the heart is, that it moves in a given *space*, and when this space is much greater than natural it denotes that effusion of pus or of serum has taken place. Lastly, the heart is a solid body, surrounded on three sides by lung; and consequently, when the portion of the chest immediately above it is struck, it returns a dull sound, while all around returns a clear one; and this enables us to determine the extent of the effusion, or, when that is wanting, the *size* of the heart. Such are the physical signs of the heart's action, and according as they are present or absent, modified or natural, we derive much assistance in determining the existence of pericarditis. Thus it is generally supposed we can determine by these symptoms whether any and what effusion has taken place into the pericardium. If, for instance, diffuse inflammation exists, it is denoted simply by pain, but without any other local symptom; if serum be effused in any considerable quantity, the pulse is still strong, and varies from 90 to 100, while the heart feels as though moving in a large space, together with "son mat" of considerable extent on percussion; if lymph is thrown out, a rubbing or crackling-of-leather-sound is heard; while, if pus is effused, the pulse is small and frequent, 120 to 130; and the heart is felt once more beating over a great extent of the chest, which gives a "son mat" on percussion. In general the pulse is accompanied by a bruit, and these symptoms continue till death closes the afflicting scene.

*Diagnosis.*—When pericarditis results from acute rheumatism, the only disease with which it can be confounded is angina pectoris; but the attack of rheumatism readily distinguishes them. The difficulty of the diagnosis in other forms of the disease has already been stated.

*Prognosis.*—Acute pericarditis from rheumatism is seldom fatal, if properly treated; but when it arises from any other cause it is far less tractable. Still, however, it is often compatible with life; for Louis found, on examining 443 bodies of persons that had died of other disease, traces of pericarditis in 1 in 11, a circumstance which shows that it is often recovered from. It must be admitted, however, that this disease renders the party

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prone to affections of the chest, and also to dropsy, and consequently it is an ultimate means of shortening life, although the patient may enjoy many intervals of perfect health.

*Treatment.*—The treatment of acute rheumatic pericarditis consists in moderate bleedings, and in the exhibition of calomel till the mouth is affected; but this will be treated of more fully under the head of Rheumatism. The treatment of acute pericarditis, the result of simple inflammation, is perhaps not dissimilar, but the cases are so few, and as yet so imperfectly observed, that the methodus medendi can hardly be said to be determined. In the more chronic forms of this affection, the mischief is for the most part irremediable; but the dropsical symptoms admit of much relief from the dried seeds of the iberis in three-grain doses three times a day; also from æther, digitalis, the bitartrate of potash, and perhaps from small doses of mercury.

### Of Carditis and of other Simple Organic Diseases of the Substance of the Heart.

Carditis is an inflammation of the muscular structure of the heart, and is extremely rare as an idiopathic disease.

*Remote Causes.*—The remote causes of this affection are rheumatism, probably violent moral affections, drunkenness, together with previous existing disease of the pericardium: the substance of the heart is also acted upon by the poison of the plague and of the small-pox.

*Predisposing Causes.* — These affections have in general been met with in early adult age, and rarely beyond the age of 50.

*Pathology.*—The muscular structure of the heart is liable to the diffuse, the adhesive, the suppurative, the ulcerative, and to the gangrenous inflammations. The cases of diffuse inflammation from acute rheumatism are numerous, but the cases recorded of the other forms of inflammation are too few to enable us to give any satisfactory generalization of their phenomena. The relation, however, of a few individual cases will establish the liability of the heart to the inflammatory diseases that have been mentioned.

M. Simonet has recorded a case of *suppuration* of the heart, in which the disease appeared to result from rheumatism. The patient, a woman, was brought to the hospital labouring under most tumultuous action of the heart, with a pulse irregular and contracted, her breathing oppressed, and her extremities cold. She was bled, but died in a few hours in a fit of syncope. Several purulent collections were found in the substance of the heart, and especially in the interventricular partition. The internal surfaces of the cavities were red in several places; the muscular structure was of a yellowish hue, softened, and torn with the least effort.

Dr. Graves was consulted by a gentleman, aged 55, who had complained of palpitation and dyspnœa, and more recently of anasarca; he suffered also from severe pain and oppression at the region of the heart. Dr. Graves detected hypertrophy and dilatation of the ventricles, and as there was a loud bellows-sound with irregular pulse, he inferred disease of the valves. The patient died suddenly a few weeks afterwards, when there was found, besides hypertrophy, and enlargement of the heart, together with some adhesions, an abscess in the walls of the heart, which contained about two ounces of pus. The valves were generally thickened, but those of the aorta were ossified, while some considerable effusion was found in both pleural cavities.

The last case which it may be necessary to mention in proof of suppurative inflammation taking place in the heart, is one that was examined by Mr. Stanley. In this instance the vessels were loaded with venous blood, and the muscular fibres were of a very dark colour, of a very soft and loose texture, and easily torn by the fingers. On a section of the ventricles numerous collections of dark-coloured pus were seen among the muscular fasciculi. Some of these were seated near to the cavity of the ventricle, while others were more superficial, and had detached the pericardium from the heart. The muscular parietes were also softened, and loaded with dark blood.

*Ulceration* of the heart has been occasionally seen from an abscess in the walls of the heart having opened either into one of its cavities, or else into that of the pericardium. It has also resulted from the softening of a cancerous tumor, or from a suppurating tubercle. Cloquet has given the case of a man, aged 79, subject to frequent syncope, who died suddenly, crying out fire! thieves! "au feu! au voleur!" and in whose heart there was an ulceration of the left auricle, through which about two pints of blood had escaped into the pericardium.

*Ramollissement* of the walls of the heart has been occasionally met with. In this affection the heart is flaccid, so that if we make an incision into the ventricles the walls collapse. Its substance also tears with great facility. This disease is almost always accompanied by some change in its colour, which is sometimes deeper than natural, and at others, according to Laënnec, of a yellowish tint, like that of an autumnal leaf,—an appearance which does not necessarily occupy the whole thickness of the muscular substance, but often merely the central layers. This degenerescence is sometimes general, but often partial, affecting only the walls of one ventricle, of the interventricular partition, or else the walls of one auricle. It is from this cause, perhaps, rather than from any other, that the patient sometimes falls from rupture of the heart.

Examples of the rupture of the right side of the heart are more rare than those of the left, or, according to Bouillaud, there are six ruptures of the left side to four of the right side. Rupture of the auricles is perhaps as frequent as that of the ventricles, or, out of the 10 cases mentioned, four were ruptures of the right auricle and two of the left auricle. The extent of the rupture, when it takes place in the ventricle, is very various. In one case the ventricle was ruptured from its apex to its base, along the sulcus which separates the two ventricles. In another, the rupture was from 10 to 12 lines; in a third, the base of the ventricles was severed from the aorta, and one of the aortic valves split transversely. It is remarkable, however, that the rupture has seldom been found at the apex, where the walls of the heart have least force and consistency. The number of the ruptures is as various as their seat; thus out of 48 cases collected by Ollivier, eight were multiplex. Again, in two cases related by Rostan, there were two ruptures in each case towards the apex of the left ventricle. Morgagni gives one case, and Portal another, in which there were three ruptures in the left ventricle, and Andral met with a third, in which there were five ruptures; but of these three were superficial, only two opening into the cavity of the left ventricle.

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Corvisart is the first who has given examples of another kind of rupture of the heart, and it is that of the carneæ columnæ, or tendons of the valves; and it is probable that rupture of these parts is owing more frequently to ramollissement, or to induration, than to any other cause. Laënnec, however, mentions a case in which it appeared to result from ulceration. In the three cases related by Corvisart, the rupture followed some violent exertion; and Bertin also saw a case in which one of these tendons was ruptured in consequence of a violent fit of coughing. The first symptom in all these cases has been a sudden sense of suffocation, and the patient has in general suddenly died, although in some instances he has survived a few days.

*Induration* of the walls of the heart is also an occasional disease of this organ. Bouillaud has collected a series of cases in which this change of structure has been observed. In one the walls of the heart were almost tendinous. In another the carneæ columnæ of the ventricle were so increased in density as to split, "casser plutôt que de rompre." In a third, the walls of the right ventricle seemed to be undergoing a cartilaginous transformation, and Broussais has seen them as hard as a cocoa-nut. The more usual mode of induration is ossification,—a change which usually begins in the coronary arteries, and frequently stops there; but in some rare cases this ossification extends, so that the walls of the auricles, of the ventricles, or both, and sometimes also of the cardiac partition, become converted into bone. There are specimens in the museum of St. Thomas's Hospital which make it remarkable how life could have been continued, looking to the unyielding nature and great extent of the ossification of the walls of the heart.

*Hypertrophy* is an abnormal increase of the muscular substance of the walls of the heart, and although occasionally an idiopathic disease, is more commonly a secondary affection, caused by disease of the valves. The hypertrophy may be general or partial, that is, may affect the whole heart, or one side of the heart, or one ventricle or one auricle, or the ventricle of one side and the auricle of the other; or else both ventricles or both auricles; or indeed every possible combination of the four cavities. The auricles, however, are much less frequently affected than the ventricles.

The natural thickness of the walls of the left ventricle is in the adult about 6½ lines; but Laënnec has seen them an inch and a half, or 18 lines in thickness at the base, when affected with this disease, or triple the healthy standard. This thickness generally diminishes towards the apex, which latter is often natural; but in other cases even the apex is thickened, and instead of two lines it measures four lines. The carneæ columnæ and likewise the cardiac partition are also proportionably hypertrophied in these cases.

In hypertrophy of the right ventricle the walls are more uniformly thickened than in hypertrophy of the left ventricle; still, however, the increased thickness is always more marked about the tricuspid valves, and at the origin of the pulmonary artery. The greatest thickness observed has been seldom more than four or five lines, which, taking the natural thickness at 2¾ lines, is scarcely a two-fold increase. In malformations of the heart, however, it has been found much greater; and both Bertin and Louis have each seen a case in which the foramen ovale was open, and in which the thickness varied from 12 to 16 lines. Besides an increase of thickness, the walls of the right ventricle, when hypertrophied, acquire a greater firmness, so that on cutting through the walls they do not collapse.

Hypertrophy of the heart seldom takes place without an alteration in the size and form of the chambers. These may indeed be natural, but more commonly they are either increased or diminished; or supposing each chamber to measure 10 square inches in health, it sometimes measures from 15 to 20, or even more; or supposing it, when of the natural size, to hold two ounces, when thus diseased it will often contain a large portion of a pint. This state of parts has been termed *eccentric* hypertrophy: and admitting the normal heart to weigh 9½ ounces, the weight in hypertrophy is often double or triple that amount; and Bouillaud speaks of 18, 20, and 22 ounces being not uncommon. On the contrary, hypertrophy sometimes takes place *concentrically*, or at the expense of the cavity of the heart, and from this cause the ventricle has been found so reduced in size as to be not larger than an unshelled almond.

*Atrophy*.—The walls of the heart may be atrophied instead of being hypertrophied, so that this organ has been found to weigh in one case only four ounces two scruples, instead of nine and a half ounces, while the thickness of its parietes was reduced to little more than a thin membrane. This atrophy may be general or partial. In some cases the atrophy takes place without any notable alteration of the capacity of the chambers of the heart, and this is termed *simple* atrophy. More commonly, however, when the walls are thinned, the chambers of the heart are enlarged, and this is termed *eccentric* atrophy. Again, the whole heart may be atrophied and reduced in size, as is often seen in phthisis. Thus Bouillaud gives the case of a woman, aged 61, whose heart was no bigger than that of a child 12 years old. While Burns gives the case of an adult whose heart did not exceed that of a new-born infant; and this form has been termed *concentric* atrophy.

*Dilatation* of the cavities of the heart, it has been stated, may exist both when the heart is hypertrophied or atrophied; but it may also exist when the walls of the heart are of their natural thickness. In any case the dilatation may be partial or general. Partial dilatation of the heart sometimes presents many curious phenomena; thus the walls of the right ventricle have been seen divided into two distinct parts, or, as Laënnec has described it, into a sort of hour-glass contraction.

In other cases this partial dilatation is perfectly aneurismal. Corvisart gives the case of a young negro, who died suffocated, and in whom the superior and lateral part of the left ventricle was surmounted by a tumor almost as big as the heart itself. The inner surface of this tumor contained many concentric layers of lymph, exactly similar to those of an aneurismal sac. The cavity of this tumor communicated, by means of a small opening, with that of the ventricle. Laënnec mentions two cases in which a tumor, of a globular form, and the size of duck's egg, was situated at the point of the left ventricle, and communicated with the ventricle by an opening an inch in diameter. In these cases the left side of the walls of the sac presented a continuation of the muscular fibres of the heart, while on the right side they appeared formed by the two pericardia. Laënnec thinks that these aneurismal tumors are formed by ulceration of the internal walls of the ventricle, as in false aneurism of the arteries; others that it is owing to a separation of the muscular fibres, and

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the protrusion of the inner pericardium. There are some fine specimens of this disease in St. Thomas's Hospital.

*Hydatids* have been found in the walls of the heart, beneath the inner membrane. Dupuytren found hydatids in the thickness of the right auricle, forming a tumor, projecting into the cavity, as large as the heart itself. Morgagni found in an old man, who had in no degree suffered from palpitation, syncope, or irregularity of pulse, but had died of acute disease, a serous cyst the size of a cherry, in the walls of the left ventricle.

*Fatty Degeneration.*—It is not uncommon to meet with the heart loaded with fat deposited between the muscles and the reflected pericardium, especially at the junction of the auricles with the ventricles; also along the trunk of the coronary veins, at the two edges of the ventricles, at the apex, and at the origin of the aorta and pulmonary artery. The right ventricle is often almost entirely covered with it, and even the left ventricle presents a given quantity about its centre. The more a heart is thus loaded with fat the thinner are its muscular walls, so that in some cases, at the apex and at the walls of the right ventricle, the fibrous structure has almost disappeared, and the carneæ columnæ consequently appear to spring altogether from the endo-pericardium. The muscular fibres, however, which remain are healthy.

In other instances the muscular fibre, instead of being displaced or absorbed, undergoes a fatty degenerescence similar to what has been observed in other muscles; and in this case the muscular fibre becomes of a yellowish colour, like that of a dead leaf, and like to that of certain softened hearts. Laënnec has generally found this steatomatous degeneration partial, and limited perhaps to the apex. In a case which occurred at St. Bartholomew's Hospital, the whole heart had suffered from this degenerescence, so that it appeared little more than a fatty bag, and it was quite extraordinary how the organ had continued to act.

*Symptoms of Carditis.*—Few authors have met with a case of carditis, unless complicated with pericarditis, and no distinction has hitherto been observed between the symptoms of these two diseases. Corvisart says it is impossible to distinguish between these affections. M. Laënnec affords us no assistance in this dilemma, for he considered that no incontestible example of carditis existed; while Bouillaud says he knows of no symptom which is especially characteristic of carditis. The little that is known of *ulceration* of the heart has already been mentioned.

The symptoms of *ramollissement* of the heart are a feebler impulse, a slower beat, and greater dulness of the sounds of the heart. Patients suffering from this affection are usually hypochondriacal, liable to palpitation on the least exertion, and often die from the ventricle rupturing.

The symptoms of *induration* of the heart are—a stronger impulse and a louder sound than usual. This class of patients is greatly subject to angina pectoris.

The symptoms of *hypertrophy* of the heart are local and general. The local symptoms are a more powerful impulsion, a wider range of action, and some change in the sounds of the heart. There is also a greater extent of dulness of sound in the cardiac region, and sometimes a bulging-out of the left side.

The increased impulsion in hypertrophy of the heart is in proportion to the greater thickening of the walls. Thus in slight cases it is only sensible to the hand, while in others the heart "knocks against the ribs," and even raises the head of the auscultator. This greater impulse, also, not only often causes a vibration of the præcordial region, but even shakes the whole of the chest. Besides being sensible to the touch, the abnormal action of the heart in these cases is often sensible to sight, each contraction agitating the patient's dress, and sometimes even moving the bed-clothes. The point of the heart also deviates more to the left, and its motions may be sometimes traced from the second or third rib as low as the sixth or seventh intercostal space.

The increased thickness of the walls of the heart is evidently unfavourable to the transmission of sound; and it is plain, therefore, that in simple hypertrophy, without enlargement of the cavity, the natural sounds will be duller than in the normal state; and also, if the hypertrophy be concentric, or with smaller cavities, that they will be scarcely heard. When, however, the cavities are enlarged, as in eccentric hypertrophy, the sounds are often clear, full, and even much louder than natural.

In hypertrophy of the left ventricle the impulse is stronger immediately under the inferior portion of the sternum than between the fifth and sixth ribs. Lavoisi has laid it down as a sign of hypertrophy of the right ventricle, that there is swelling of the jugular veins, which now pulsate synchronously with the carotids. Corvisart has repudiated this symptom, but Laënnec says he has found it in every case he has seen of hypertrophy of the right ventricle. In general this pulsation is limited to the inferior parts of the jugular veins, but in other instances it has been seen to extend to the superficial veins of the arm. He regards this symptom, therefore, as one of the best diagnostics of hypertrophy of the right ventricle.

In estimating the general symptoms of hypertrophy of the heart, our knowledge of the influence of the left ventricle over the arteries would lead us, *à priori*, to infer that one of the effects would be a disposition to congestion and to hæmorrhage; and that apoplexy, hæmoptysis, and hæmorrhage from the bowels would often result. It appears, according to Bouillaud, that this reasoning is correct; for out of 54 cases of hypertrophy of the heart, 11, or one-fifth, were attacked by cerebral hæmorrhage or central ramollissement. As many, perhaps, suffer from pulmonary hæmorrhage, while a few suffer from hæmorrhage from the bowels. Indeed, on opening bodies that have died of this disease of the heart, we find the abdominal viscera and mesenteric veins loaded with blood. More commonly, perhaps, hypertrophy is connected with many diseases of function, as asthma or dropsy. The causes of this conjunction with asthma are not very well understood; but it probably arises from the circumstance, that when one branch of the eighth pair, or that supplying the heart, is affected, the other branch which supplies the lungs must partake of the disease, and hence asthma. The causes of its conjunction with dropsy is, that the heart acting too forcibly, the capillary system becomes congested, and serum is effused. The conjunction of hypertrophied heart is also very common in albuminous dropsy; but whether it is a primary or a secondary affection has been disputed, some considering the diseased state of the kidneys to be caused by congestion, induced by the state of the heart, while others consider the kidneys to be primarily affected, and the disease of the heart to be caused by the impoverished condition of the blood; and this latter is certainly the most proba-

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ble theory. Besides these concomitants, a pouchy or otherwise diseased state of the aorta often co-exists with hypertrophied heart,—the diseased aorta being caused by the abnormal power of the heart, or else the hypertrophy of the heart results from a supplemental force being necessary to compensate the lost power of the aorta. Many persons affected with hypertrophy of the heart suffer severely from angina pectoris, with palpitation, but it is singular that in general the pulse is natural, except the patient be excited, when it is full and strong.

The symptoms of *atrophy* of the heart are also local and general. The local symptoms are, a feeble impulsion of the heart, while its sounds are louder, clearer, and more distinct than in health; the intensity of sound being greater in proportion to the atrophied state of the walls, combined with increase of size of the chambers of the heart. The general symptoms are, slowness of the pulse, occasional palpitation, difficulty of breathing, and tendency to dropsy. It may appear singular, that as nothing can be more opposed than hypertrophy and atrophy of the heart, that dropsy should equally occur in both cases; but the loss of power of the heart causes a remora or stasis of the blood in the capillary system, equally with its excess of power, therefore the same consequences result. This disease, it has been stated, sometimes terminates by rupture of some chamber of the heart.

The symptoms of *dilatation* of the chambers of the heart, when the walls are of a natural thickness, are merely an augmentation of sound, while their *contraction* is known by a diminution of sound. Aneurism of the heart is so rare that its symptoms can hardly be said to be determined. The celebrated Talma, among other affections, had an aneurismal tumor as large as a pullet's egg on the apex, but no such affection was suspected during life. Most of the specimens in our museums have been obtained from the dissecting-room, and consequently without any previous knowledge of the case. It is probable, however, that the symptoms must be some bruit and some frottement conjoined with some irregular action and displacement of the heart. Hydatids of the heart have likewise as yet no determinate symptom; and little is known of the phenomena resulting from fatty degenerescence, except that the pulse is feeble and the impulse trifling.

*Diagnosis.*—The diagnostic symptoms of carditis, of ramollissement, and of induration of the heart, are imperfectly known. On the contrary, the symptoms of hypertrophy of the heart, and of enlargement of its chambers, are so striking that it is impossible to mistake them; but it should be remembered they are often latent, unless aroused by some mental emotion, or sharp exercise. Hydatids and fatty degeneration, it has been stated, are too infrequent to allow us to consider their diagnostic symptoms as determined.

*Prognosis.*—It is probable that diffuse inflammation of the substance of the heart often exists, and is often recovered from, but if any morbid product forms in it the prognosis is fatal. Ramollissement, as well as induration of the heart, from the tendency to rupture in the one case, and to ossification in the other, if they can be determined to exist, are always of grave prognosis, although the patient perhaps may survive many years. Hypertrophy, atrophy, or dilatation of the heart, are perhaps compatible with health, till dropsy or hæmorrhage takes place, when the conjoint diseases are either most difficult of cure or else fatal. Hydatids of the heart are fatal, but fatty degenerescence is perhaps compatible with prolonged existence.

*Treatment.*—What little we know of Carditis would lead us by analogy to imagine that the cure of diffuse inflammation is by bleeding and mercury, so as to affect the constitution. If pus, however, should form, no remedy promises to be beneficial. We possess no determinate remedy for ramollissement, and should such disease exist the best chances for the patient are, attention to his general health, country air, with a liberal diet. An indurated state of the heart is perhaps little influenced either by mercury, or the iodide of potash, or any other alterative medicine; and the treatment consequently resolves itself into mitigating the attacks of angina, by which it is so usually accompanied, by means of opiates, æther, and camphor.

"Of all the organic affections of the heart," says Laënnec, "hypertrophy, with or without dilatation, appears to me the most susceptible of cure. But to obtain this success it is necessary that the physician, as well as the patient, should arm themselves with equal firmness; for it requires no less tenacity of purpose in the latter to support frequent bleedings, and a perpetual fast, than in the former to contend with the opposition of parents or of friends, and the discouragement which must at times take possession of the patient, who must endure this treatment for many months, or perhaps many years."

This treatment laid down, probably theoretically by Laënnec, is certainly not found to be practically beneficial; for bleeding very constantly, instead of quieting the impulsion, only renders the heart more irritable and its action greater. Again, such an amount of bleeding as would affect the heart would probably debilitate the already weakened capillaries in a still greater degree than the heart, and consequently determine the dropsy which so often ensues. As a general principle, therefore, Laënnec's views should be adopted with much caution; for with respect to bleeding, much observation has shown that it is rarely beneficial, except the hypertrophy be accompanied by hæmoptysis; and in such case moderate bleeding, with the inf. rosæ c. tinct. digitalis ♏ viij. to xij. c. magnes. sulphatis ʒ ſs. to ʒ j. is the best treatment. When, however, hypertrophy of the heart is unaccompanied by hæmorrhage, we usually find that quiet, with some transient stimulant, as mist. camph. c. sp. æth. nitr. ʒ j. e. sp. ammoniæ aromatici ʒ ſs. ter die vel 6tis horis, tranquillizes its abnormal action far more successfully than any other treatment. If the hypertrophy be accompanied by dropsy, the semina iberidis exsicat. gr. iij. to gr. v. are perhaps the most powerful remedy; but should this fail, other diuretics, as the bitartrate of potash, elaterium, or acetate of potash, with squills, may be tried.

No remedy is known for atrophy of the heart, except a generally tonic treatment. Neither is it possible to restore the enlarged chambers of the heart to their natural dimensions, although by care life may be enjoyed for many years. Hydatids of the heart are perhaps irremediable; and fatty degenerescence can only probably be mitigated by an alteration of the patient's habits of life.

*Endocarditis* is an inflammation of the serous membrane forming the valves and lining the chambers of the heart. The diseases of this membrane are by far the most frequent of all the affections of the heart, and often lay the foundation of all the other forms. Indeed



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it may be said to constitute at least 19-twentieths of all the diseases of this organ.

*Remote Causes.*—The inner membrane of the heart, exposed as it is to the action of many morbid poisons, and also, we should imagine, to many medicinal and other substances taken up by the absorbents and introduced into the circulation, renders it singular that it is not found still more frequently diseased than it really is. Of all classes of substances, however, alcohol has the most striking effects on this tissue; for this fluid is not only proved to be absorbed and actually to circulate in a free state in the blood, but there are few drunkards the inner membrane of whose heart and large vessels is not more or less diseased; so that this fluid probably acts as a specific poison on that part. The rheumatic and gouty virus appears to act upon this tissue, and many persons improperly treated for those complaints often ultimately die of some form of endocarditis.

*Predisposing Causes.*—It is very rare to find disease of the inner membrane of the heart in children, but occasionally ossification of the valves has been seen as early as 10 years old. As a general rule, however, these affections commence with early puberty; and two boys, about 16 years old, are now in St. Thomas's Hospital labouring under endocarditis. This tendency increases with age, so that there are few old persons the inner membrane of whose heart and arteries is not more or less diseased. Women are by no means free from these complaints, but from their more temperate habits they are less prone to them than men.

*Pathology.*—As the pathological phenomena of the membrane lining the *right* side of the heart are in many respects different from those of the *left* side, it consequently seems best to consider them separately.

The internal membrane of the left side of the heart is liable to the diffuse, the adhesive, and to the ulcerative inflammations; and these inflammations may attack either the chambers or the valves of the heart, or both; but, like all hollow organs, the orifices and valvular structure are, by a species of preference, by far the most frequent seat of disease. They may be either acute or chronic.

Acute diffuse inflammation of the membrane lining the left chambers of the heart is occasionally seen after the application of a ligature round an artery, for the cure of a femoral or other aneurism; the inflammation thus caused spreading along the serous membrane of the artery till it reaches the heart. This form of inflammation, so demonstrable in surgery, is occasionally seen in medicine, and may invade the chambers either of the auricle, the ventricle, or both. The inflamed membrane is of a bright rose colour, its structure something thickened, and it is more easily detached than usual. The student, however, should be warned that the colour may be similated by transudation of the colouring matter of the blood, after death, staining the membrane. There is no evidence of the inner membrane of the left chambers being the seat either of serous or of purulent inflammation; for, if those forms do exist, the morbid product is swept away in the torrent of the circulation. It is, however, liable to the adhesive inflammation; and instances are met with of lymph being attached to the inner surface of the left auricle, and in considerable quantities, though perhaps not organized. Another proof of the adhesive inflammation is the membrane of both chambers being occasionally found greatly thickened, silvery, and opaque. Again, this tissue is liable to the ulcerative inflammation; and a student of St. Thomas's Hospital died from this cause a few years ago. In the chronic forms of inflammation this membrane, in a few instances, is found to be the seat of cartilaginous or ossific deposits.

The valves of the left side of the heart, like the inner membrane of its chambers, are unquestionably liable to the diffuse, the adhesive, and to the ulcerative inflammation, and these may be acute or chronic.

Diffuse inflammation of the valves is often seen, the tissue being of a rose colour and thickened. The valvular tissue is also the seat of adhesive inflammation, both at its free and at its cellular surface. The instances of its occurring at its free surface are extremely numerous and well marked. Thus lymph is occasionally found strongly adherent on the external surface of the valves, and this lymph occasionally becomes organized, forming those fringe-like or fibrinous warty growths which are often met with on the mitral or aortic valves. It is by this process that the three aortic valves, or else the mitral valves, are sometimes found all soldered together; so that, except for the contraction which takes place in all inflamed parts, the orifice would be closed; but, notwithstanding that process, it has been found sometimes a mere slit, or even reduced to the size of a goose-quill; while Corvisart speaks of an instance in which the orifice, which in health is upwards of three inches in circumference, was reduced to three lines in diameter. In other instances only one valve is affected; and this may be turned up and bound to the aorta, or it may be turned down and bound to the inner surface of the heart, or it may be rolled up, taking the form of a shell, and two or more of these circumstances may co-exist in the same heart.

Adhesive inflammation of the inner or cellular surface of the valves is seen by their often becoming greatly indurated and thickened, so that their action is much impaired; or these changes may be limited to the fibrous zone which forms the base of the valves, surrounding the aortic orifice with a sort of collar, contracting its diameter as well as impeding the play of the valves. In other cases the thickening may affect the free edge, or else the central portion of the valve, as the tubercula arantia. The most remarkable circumstance, however, connected with chronic adhesive inflammation of the left side of the heart, is the excessive tendency which the valves have beyond all other serous tissues to become cartilaginous or ossified. These new formations sometimes originate in the substance of the serous tissue, but more commonly are deposited in the subcellular tissue connecting the duplicature of the valvular fold. This ossific deposition is not necessarily preceded by a cartilaginous formation, but is most frequently an original abnormal secretion, often containing a good deal of earthy matter. It is deposited in various forms: sometimes in layers, at others in points, and at others in large masses, knobbled or pyramidal, and occasionally acquiring a large size, so much so that Bertin saw one as large as a pigeon's egg. Sometimes the tendons, or the chordæ tendineæ attached to the mitral valve, participate in these indurations, and Corvisart met with one entirely ossified; and when thus indurated and rendered brittle they sometimes rupture, and the patient dies perhaps in a few minutes. The irritation of these deposits often causes the membrane to ulcerate, and the ossific matter, exposed and discoloured by being bathed in the current of the

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Elementary Principles of Medicine.

blood, has been mistaken for caries. Ulceration, however, sometimes takes place superficially without any such irritating cause, and the valves are even occasionally found perforated.

As the diseases of the veins differ greatly from those of the arteries, we should consequently expect that the diseases of the right side of the heart would in many respects differ from those of the left; and this is the case: for although the inner membrane of the right side of the heart is liable to the diffuse, the adhesive, to the ulcerative, and perhaps to the suppurative inflammations, still it is very rarely the seat of cartilaginous or of ossific deposits.

Acute diffuse inflammation of the serous membrane of the right side of the heart has often been seen in surgery, in consequence of inflammation of a vein spreading to the right cavities of that organ: and by many medical writers this is supposed to take place idiopathically. Serous inflammation is not known to exist in the veins, neither is it proved to affect the right side of the heart. Suppurative inflammation, however, does often affect the veins, sometimes forming a long chain of abscesses, and consequently may affect the right side of the heart; but if so, the morbid product is instantly removed, and consequently the fact is doubtful. The adhesive inflammation, however, though by no means so frequent as on the left side of the heart, is far from being unusual. This is evidenced by the tricuspid valve being often found thickened and bound down, so that the auriculo-ventricular opening is greatly narrowed. The sigmoid valves have also been found similarly diseased, so that, instead of being 3 inches in circumference, the pulmonary orifice is so greatly reduced as sometimes not to have exceeded 4, 3, or even 2½ lines in diameter. Lymph has also been found, as is supposed, effused at the free surface of the right auricular serous membrane. Ulceration also occasionally takes place in this membrane, the septum of the heart having been found perforated, and the pulmonary valves occasionally are seen in a similar state.

The cartilaginous and osseous formations so common on the left side of the heart, are infrequent on the right side; still, however, they have been met with, and more especially when from any congenital malformation, or other cause, the right and left sides of the heart have communicated, and the arterial and venous blood of those cavities been mingled. Morgagni gives the case of a young woman, aged 16, in whom the valves of the pulmonary artery were cartilaginous, with a point of ossific matter, and were so adherent that the orifice was greatly contracted. In this case the foramen ovale was open, and the patient laboured under cyanosis, or the blue disease—"Maladie bleu." Vieussens, Hunauld, Bertin, and others, have seen instances of osseous or of cartilaginous indurations of the right side of the heart. But the most extraordinary case of this kind is that observed by Cruwel in an octogenarian. In this case the tricuspid valve was cartilaginous in many points, and osseous lamellæ extended from the base of the right auricle, behind the internal membrane of the right ventricle, of which some of the columns were ossified. Small osseous concretions were also observed in the vena cava. A small globular body, pierced with two openings, with cartilaginous walls, and partly ossified, was *enclavée* between the valves of the pulmonary artery. Some ossifications also existed on the left side of the heart, and in the pericardium.

A diseased state of the valves, whether of the right or of the left side of the heart, is usually accompanied by atrophy or hypertrophy of its walls, and also with dilatation of the different chambers of the heart. These abnormal states arise from the circumstance, that any impediment to the circulation situated at the orifices of the heart, or any alteration in the form of the orifice, affects the quantity of blood discharged, and calls on the heart for increased exertion, and thus leads to an alteration both in the strength of its walls and the size of its chamber. Thus, supposing the aortic orifice to be diminished from any cause one-half, it is the law of the discharge of fluids through orifices, that the quantity of blood propelled through them by the same force is reduced to *one-fourth*, and consequently the heart will be required to exert a *four-fold* force, should such an event occur, in order to transmit the usual quantity of blood, and to carry on the circulation. This call on the heart's powers may perhaps be met in some few sthenic individuals, and the walls become so greatly hypertrophied as to supply by an increased velocity the diminished quantity of blood which must otherwise be thrown out at each systole of the heart. But more commonly the heart, even of a powerful man, is seldom long able to contend with a permanent obstacle, and much less so that of a patient of a feeble habit, and consequently the physical force of the heart gives way. In either of these cases, also, a *remora* of the blood takes place in the chambers of the heart, it accumulates, and they enlarge. The most usual alteration is a pouchy state of the ventricle at the insertion of the aorta, so that its orifice is no longer in the direct line of the axis of the heart, and the counter currents, as well as physical obstruction thus produced, still further diminish the discharge. It follows as a necessary consequence, then, that any change in the form of the orifice, or of the ventricle, or any obstruction caused by the valves, necessarily contribute to an hypertrophied or atrophied state of the heart, and to an enlargement of its chambers.

The changes which have been mentioned once established, the evil goes on increasing; for, supposing the chamber of the ventricle to average 10 square inches, and each square inch to exert a force of 4 lbs., the whole force that the cavity exerts at each contraction is 40 lbs. If, however, the chamber of the heart become enlarged to 11, 12, or 15 square inches, the force to be exerted will be increased from 40 lbs. to 44, 48, 60, or even more pounds; thus the distending force increases with the weakness and dilatation of the cavity, and renders a return to a healthy state almost impossible. The heart, then, once enlarged, often continues to increase, till at last its chambers acquire such a size that the valves are no longer capable of closing their respective orifices, and "a permanent patency," as it is termed, ensues; when the column of blood making a constant pressure on the ventricle, the powers of the heart are rapidly exhausted, and the patient shortly dies. The distending force acts equally, or nearly so, on all parts of the dilated chamber; but if the walls of the heart be enfeebled at any given portion, that portion sometimes giving way, the heart may rupture, or else the aneurismal tumors of the heart that have been mentioned form. Such are the mechanical laws which govern this class of disease.

*Symptoms.*—The cases of acute inflammation of the inner membrane, lining the chamber of the ventricle or of the auricle, are so few that their symptoms are by no



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means determined. They are generally, however, considered to be delirium, fever, and an exceedingly irregular pulse, together with much anxiety and oppression at the præcordia.

Acute inflammation of the valves of the aorta is seldom seen, except combined with rheumatism; and the physiological symptoms are pain or angina of the chest, while the physical contractions of the heart are marked by a "bruit de soufflet."

In chronic inflammation of the valves there is no pain, nor is it until the play of the valve is impaired, or the orifice contracted, that it gives rise to any well-marked physiological or physical symptom. The physiological symptoms are—a frequent irregular pulse, occasional palpitations, asthma or cough, with bronchitis. These disordered actions of the organs of the chest are at length followed by the capillary system giving way, either from sympathy with the diseased state of the heart, or else from mechanical congestion, and hæmorrhage and dropsy are the most frequent consequences, so that the patient most commonly dies either from apoplexy, or hæmorrhage from the lungs or bowels, or else from hydrothorax, ascites, or some more general form of dropsy. It is remarkable, however, that as soon as the dropsical effusion has taken place, the pulse generally becomes slower and the bruit less loud. But these apparently favourable symptoms are not followed by any amendment; on the contrary, the dropsy increases, and the two diseases quickly destroy the patient. It is singular, also, and marks an advanced stage of the disease, that the pulse is in many cases not synchronous with the systole of the ventricle, which shows that in disease the arteries have an action independent of that of the heart.

The physical symptoms which denote a diseased state of the valves are, the peculiar bruit and the impulsion. In health it has been stated that the contractions of the ventricle are accompanied by a peculiar sound, and that of the auricles by another; but when the valves of the heart are diseased, these natural sounds are changed into what is technically termed a "bruit," or an abnormal modification of the natural sounds. The peculiar character of the bruit depends on the degree in which the orifice is contracted, and also on the state of the valve itself, or whether it be rough or smooth. If smooth, we have generally a "bruit de soufflet," or bellows-sound; if, on the contrary, the valve be fringed, or ossified, or otherwise irregular, we have a rasping, filing, whistling, and sometimes even quite a musical sound. The rule for determining the particular valve affected is, if the sound be heard loudest on a level with the lower edge of the third rib, and a little to the left of the mesial line of the sternum, it is the aortic valve which is affected; and on the contrary, if the sound be heard loudest more to the left, and between the fifth and sixth ribs, it is the mitral valve. When, however, it is remembered that the valves of either orifice are contiguous, and in the same line, it will be plain that much difficulty must and does exist in determining the particular valve affected. Sometimes both valves are affected, and then we have a double "bruit."

When the orifices of the heart are so dilated, or the valves so bound down that they cease to close the orifice, a permanent patency, as it is termed, is established. If the defect of the closure be inconsiderable, this also causes a double bruit; the first taking place on the contraction of the ventricle, and the other on its relaxation, caused, as is supposed, by a *regurgitation*. If, on the contrary, the orifice be greatly enlarged, so that the column of blood rests on the ventricle, hardly any bruit is heard, and the incessant effort the heart is now obliged to make to free itself from the blood at length so enfeebles it that the pulse becomes a mere flutter, and the patient rapidly sinks. Again, if the orifice be a mere slit, the same absence of bruit has been observed, the powers of the heart being probably so reduced as to be only capable of exciting a force sufficient to furnish the quantity of blood equal to that discharged by the diseased orifice. As a general law, when the valves are diseased the intensity of the sound varies directly according to the size of the chambers, combined with the degree of the hypertrophy of their walls, the sound being loudest when increased size is united to increased power. As a general law, also, the intensity of the impulse varies directly according to the degree of hypertrophy of the walls.



*Diagnosis.*—The diagnosis of disease of the valves of the heart is sometimes difficult in slight cases, from our liability to confound the respiratory bruit with the valvular bruit; but a little attention and a repeated examination will remove this error. Another circumstance of difficulty in the diagnosis is, that when the valves are greatly diseased, and the heart rolling, the quantity of blood projected at each contraction is so small that no bruit is produced. Under these circumstances, the patient should be kept quiet for some minutes, when the circulation will become more tranquil and the bruit will return, and often be loudly heard. Position, also, as lying on the back, diminishes the intensity of the sound, the heart in this posture circulating the blood with less difficulty.

*Prognosis.*—In every case of diseased valves, the prognosis is unfavourable; indeed, hardly an instance is met with of perfect recovery. The patient, however, often survives many months, and even some years, if he can command the comforts of life without the necessity of personal exertion.

*Treatment.*—Endocarditis, from whatever cause, is one of the most intractable diseases we are at present acquainted with. A few patients do recover after the establishment of the bruit, but it is probable in these cases the bruit must be caused by some irregular muscular contraction of the heart, and not from actual disease of the valves. For when the valves are thickened, indurated, or united by inflammation, there is no authenticated case of the patient's being again restored to health. Such an obstacle consequently appears to be permanent; for neither mercury, nor the iodide of potash, nor any known metal, salt, or acid, purgative, emetic, or tonic remedy seems to have any power to remove it. It will be plain, also, if the obstacle be permanent, that bleeding to any amount will cause debility, and facilitate probably the occurrence of the more severe and fatal symptoms; and this operation should seldom be had recourse to, unless the patient suffers from a considerable hæmoptysis. It is difficult, since this affection is followed by asthma, dropsy, and so many different trains of disease, to lay down any given rules of treatment; but gamboge gr. ij. c. opii, gr. fs. ter die, the seminum iberidis gr. iij. ter die, tinct. digitalis ♏ viij. to xij. ammonia, camphor mixture, and æther, and the bitartrate of potash are among the most efficient remedies we possess. These always palliate the symptoms; but an apparent cure is almost always shortly followed by a relapse.

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The diet of the patient should be light but nutritious, and when these qualities are conjuined its particular nature is perhaps not important.

The diseases of the aorta and large arteries often play a great part in medicine; but as the diseases of the arteries must necessarily be treated of in surgery, we purposely omit them.

## Order II.—Of Rheumatism.

Rheumatism is a peculiar inflammation of the fibrous tissues, especially of the muscles, tendons, aponeuroses, bursæ, capsular ligaments, cartilages, and bones. It differs from ordinary inflammations in its little tendency to ulceration, and also in its great tendency to metastasis, or to shift from part to part.

This disease derives its appellation from ρεω, to flow; it being the opinion of the old physiologists that the different humours of the body were first sublimed, then condensed in the brain, whence they flowed to different parts of the body, and when over the fibrous tissues they produced rheumatism; 1030 persons are said to have died of this affection in 1838, and 946 in 1839, in England and Wales.

*Remote Causes.* — There are few morbid poisons which do not produce pains which cannot be distinguished from rheumatism: thus typhus fever begins by pains in the bones and muscles, and often ends with severe pains in the legs. The paludal poison also often leaves severe hemicrania, or rheumatic affection of one side of the head. In small-pox the patient often suffers for several days from pains which have frequently been mistaken and treated for rheumatism. In scarlatina the joints are often the seat of the severest rheumatic inflammation; while in syphilis nothing is more common than for the patient to be long racked with what appear to be rheumatic pains. It is plain, therefore, that morbid poisons are a frequent cause of a condition of parts which cannot be distinguished from rheumatism; and it is a question whether some undefined miasm of this class is not therefore by far its most frequent cause; again, if we look to the course of the disease, it differs from all ordinary inflammations in the tendency it has to subside in one part and to appear in another, phenomena explicable on the laws of morbid poisons, but which are opposed to all we know of the laws of ordinary inflammation. Supposing this view of the case should ultimately prove correct, it will follow that cold and wet, by lowering the vitality of parts, greatly assist in pointing to the particular seat of the action of the poison, but are not the great agents in the production of this disease.

Any more express investigation into the remote causes of rheumatism is extremely unsatisfactory. They are generally supposed to be identical with those causes which produce catarrh; still in all probability catarrh itself depends on a morbid poison. Those, however, who refer catarrh to the vicissitudes of temperature, attribute rheumatism to this cause; but the returns of rheumatism occurring in the different commands of our army seem to shake this hypothesis: they are as follows:—

| — | Jamaica. | Nova Scotia and New Brunswick. | Bermuda. | Malta. | Ionian Islands. | Gibraltar. | Canada. | Mauritius. | Windward and Leeward Command. | United Kingdom. | Cape of Good Hope. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ratio per 1000 . . Annual mean strength | 29 | 30 | 33 | 34 | 34½ | 38 | 40 | 46 | 49 | 50 | 57 |

"Thus," says Major Tulloch, "we find in the mild and equable climate of the Mediterranean or the Mauritius the proportion of rheumatic affections is even greater than in the inclement regions of Nova Scotia and Canada; and though some of the provinces of the Cape of Good Hope have occasionally been without rain for several years, yet rheumatism is more frequent in that command than in the West Indies, where the condition of the atmosphere is as remarkably the reverse." Exposure to wet, however, would appear to have much influence in the production of rheumatism, for we find the returns of the navy show a considerably larger proportionate number of attacks than in the army. The number per 1000 annual mean strength attacked in the Mediterranean fleet being 63·9, in the West India and North American station 69, and in the South American station 72·3.

Some writers have supposed that the cause of rheumatism lies not so much in the abstract degree of cold as in the range of atmospheric vicissitudes; and Dr. Haygarth has estimated that the number of persons attacked with rheumatism in summer is to those attacked in winter in the ratio of 5 to 7. But Hippocrates says, it is not in the heats of summer and depths of winter, when the variations of temperature may be supposed to be a maximum, but rather in the spring and autumn, when the weather is warm but variable, that rheumatism most frequently prevails.

Whatever may be the remote cause of rheumatism, Dr. Haygarth thinks it remains latent from 2 to 6 days, while Giannini extends the period to a fortnight. Chomel, however, conceives it may in some cases be brought into action in from 12 to 24 hours.

*Predisposing Causes.*—A very small number of children suffer from rheumatism; for out of 73 cases given by Chomel 2 only were attacked under 15 years—35 for the first time between 15 and 30—22 from 30 to 40 —7 cases from 45 to 60—and 7 cases after 60. At whatever age, however, rheumatism occurs, one attack establishes a predisposition to another, so that at last many persons are never free from it but are martyrs to this affection. Men are supposed to be more liable than women to rheumatism, and Dr. Marlow says in the ratio 137 men to 89 women. After menstrua-

tion, however, has ceased this greater immunity terminates

*Pathology.*—The essential nature of rheumatism in its simplest state is a mere *neurosis*, the inflammatory state, though common, being consequently an occasional accident, for many patients have died after long suffering from rheumatism, and, having been carefully examined, not the slightest trace of inflammation has been discovered in the affected limb or joint. Whichever form of this affection takes place, it has a tendency, says Dr. Budd, which "repeats itself in the fellow limb, not merely with a general correspondence of situation, but joint for joint, bursa for bursa, sheath for sheath,"—shooting sometimes from part to part with the violence of a galvanic shock, and occasionally attacking two legs of the vital tripod, or the heart and brain.

The parts affected in rheumatism are so numerous, being ligaments, fascia, aponeurosis, periosteum, perichondrium, bones, muscles, tendons, bursæ, and the serous membranes of the heart and brain, that it is impossible, within the limits prescribed to us, to enter minutely into the pathology of rheumatism; all we can do is to state generally that these parts are liable in rheumatism to be the seat of diffuse, of serous, of adhesive, and sometimes of purulent as well as of ulcerative inflammation; and these inflammations may be acute or chronic, chromatous or achromatous.

When the patient has fallen from an attack of acute diffuse rheumatic inflammation, the muscles of the affected joint, or of the heart, have been found evidently injected, and of a deep venous red or black colour. Also, the synovial membranes, the pericardium, and the membranes of the brain, when those tissues have been affected, have likewise been found red and injected, thus affording abundant evidence of the existence of diffuse inflammation in acute rheumatism.

The diffuse inflammation may terminate by resolution, or serum may be effused. *Serous* inflammation is extremely common, and is evidenced by the swollen state of the bursæ and parts external to the joint, often by an evident fluctuation within the cavity of the joint; and should the patient fall, we often find the cavity of the arachnoid and of the pericardium loaded with serum, the latter often to the extent of many ounces.

Adhesive inflammation is one of the most frequent results of acute rheumatism. The cellular tissue surrounding the diseased articulation being not only found thickened, but also often infiltrated with a loose coagulable lymph. The tendinous sheaths and capsular ligaments also often offer the same alterations. After an indefinite time the effused lymph becomes organized, and in this manner parts are bound down and the motion of joints greatly and sometimes permanently impaired. The alterations of the synovial membrane are not the least curious of the changes which occur in rheumatic joints from adhesive inflammation, for this tissue is not only often thickened, but villous processes, like the papillæ of the tongue of herbivorous animals, only soft and red, and dipping into the depressions around the neck of the bone, are occasionally formed, which are not only intractable even to long treatment, but often render the amputation of the joint necessary. The strongest evidence of adhesive inflammation is, however, the immense effusion of lymph which often takes place in rheumatic pericarditis, sometimes covering the whole surface of the heart and pericardium with a layer of lymph half an inch in thickness, and whose irregular surface has been compared to a honeycomb, a calf's stomach, or to the rind of a pine-apple.

Suppurative inflammation is so rare a termination of even acute rheumatism that many writers have denied its existence altogether. Stoll, however, has noticed this termination, and many other physicians have observed the same fact sometimes in the muscles, but more commonly within the capsules of the joint. Of this last form of disease Chomel has seen three cases, Moreau one, Piorry two, and Cruveilhier three cases; and to these Bouillaud and Macleod have made several additions.

Ulcerative inflammation is by no means unusual, sometimes perforating the capsular membrane or destroying the ligaments, but more frequently eroding the cartilages and the ends of the bones.

The chronic forms of rheumatism are principally achromatous; and this is strongly seen in ulceration of the cartilages without the trace of a red vessel. Whilst the absorption of cartilage is going on, a remarkable change sometimes take place in the bones, which are sometimes enlarged, and almost eburnified from increased ossific deposit, causing not only a change of form in the articular extremity, but presenting a mechanical obstacle to the motion of the joint. When the hip-joint is affected, says Dr. Todd, the acetabulum becomes deeper and wider than natural, and the head of the femur flattened and expanded, assuming something of the shape of the turnip. In this diseased state the bones have been found by Dr. Macleod to contain urate of soda. Portal states also that he has found the bones so soft in rheumatism that they might be cut with a knife.

*Symptoms.*—Rheumatic inflammations may be acute or chronic, but the proportion of the latter is infinitely greater than of the former.

Acute rheumatism is a severe inflammation of the feet, or of the hands, or of the larger joints, as the wrist, ankle, knee, hip, elbow, and shoulder joint, or of one or more of these parts, and this is usually accompanied by a sharp inflammatory fever. These affections often constitute the whole disease; but in a given number of cases, either with or without the subsidence of the articular inflammation, the heart or pericardium, or else the membranes of the brain, become the seat of the rheumatic inflammation. The proportion of persons whose heart is thus affected probably varies according to the treatment. Bouillaud estimates the number at more than one-half, or as 64 in 114 cases, and Dr. Macleod at one-fifth; but even this latter calculation is probably in excess. The affection of the membranes of the brain is much more rare, so that the proportionate number is not determined.

In an attack of acute rheumatism the fever often precedes, by twenty-four or forty-eight hours, the inflammation of the joints; but this is not constant, for in some instances the local and general symptoms are contemporaneous, while in others the inflammation of the joints is established before the accession of the fever.

The fever which attends acute rheumatism is well marked and striking. The chilliness or shivering with which, in common with other acute fevers, it is ushered in, speedily passes away, and is followed by great heat of the skin, and by copious but partial perspiration,

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almost invariably acid, reddening litmus paper, and of a disagreeable odour; the pulse rises to 90, 100, and 110, and is large, full, and strong; the tongue is greatly loaded with a white or yellowish-white mucus; the bowels sluggish; the evacuations dark and offensive; and the urine scanty, with a copious deposit of the lithates. There are many remarkable differences between this and ordinary fever, for it runs no given course, is not marked by changes of the tongue, nor by any great depressing action; while delirium and even headache are of rare occurrence.

The local symptoms which accompany the inflammation of the articulations are pain, heat, redness, and tumefaction. The *pain* is generally active and severe, although in a few cases it is latent,—that is, the patient is at ease, unless the joint or limb be moved. It has many degrees of intensity, being in a few instances trifling, but more commonly atrocious and agonising, and though generally constant, it is sometimes intermittent. In all cases in which it exists, it is greatly augmented by pressure, so that the slightest touch—even the weight of the bed-clothes—is insupportable; and, by an inexplicable law, it usually somewhat remits during the day, and is aggravated at night. The *heat* of the inflamed joint is constantly increased, the thermometer indicating a temperature of 100, 105, or even more degrees. *Redness*, though not universally present, is nevertheless the rule of the disease, and the affected joint is surrounded by a rose-coloured flush, evanescent on the slightest pressure, yet returning on its removal. The *tumefaction* of the part caused by the effusion of serum into the synovial cavity, or into the cellular tissue and other parts surrounding the joint, is often great, generally indeed so considerable that the shape of the hand, the ankle, or other joint, is completely destroyed. In affections of the knee the patella is often more or less displaced, by effusion into the cavity of the joint; and this, together with the swelling of the external parts, renders it misshapen, rounded, and obliterates all the markings of its healthy state.

Such are the general and local affections in acute rheumatism, and at the height of the disorder it is difficult to conceive a more complete picture of helplessness and suffering than that to which they reduce the patient. A strong and powerful man, generally unused to disease, lies on his back motionless, unable to raise his hand to wipe the drops which fast flow from his brow, or the mucus which irritates his nostril. Indeed, he is so helpless, that he is not only obliged to be fed, but to be assisted at every operation of nature. The sweat in which he lies drenched brings him no relief; his position admits of no change; and if he sleeps, his sleep is short, and he wakes up with an exacerbation of suffering which renders him fretful, impatient, and discontented with all around him.

The duration of acute rheumatism is very various; in some cases both the fever and local pains are gone in three or four days, but in the majority of instances they continue till about the tenth to the fourteenth day, when the fever disappears and the pains begin to subside, and towards the close of the third week or the beginning of the fourth, the patient is recovered, and generally without injury to the joints affected. In almost all cases, however, the pain continues till after the fever is gone, and sometimes for a very long period afterwards. The patient, though recovered, is liable to relapse, and often suffers from it.

The symptoms which have been described, constitute the usual forms of acute rheumatism; but in a given number of cases this course is interrupted by the heart, the pericardium, or else the membranes of the brain becoming the seat of this severe affection.

About the middle period of an attack of acute rheumatism, and sometimes towards its close, the heart is often affected with rheumatism even when the original attack is not of the severest character. The symptoms which mark it are pains or soreness all over the chest, increased on pressing between the intercostal spaces, and also on taking a deep breath. The patient also is restless—his countenance anxious, and occasionally he coughs. On applying the stethescope to the chest, the bruit de soufflet is often heard loud and permanent, and evidently arising from some irregular contraction about the orifices of the heart, or else from some affection of the valves. Many pathologists, it has been stated, conceive we can determine the exact pathological state of the pericardium. Thus, if the inflammation be diffuse, we shall have a crackling sound, like that of new leather, the parts being dry; or if serum be effused, we shall find the heart moving in a larger space than usual. Again, if lymph be poured out, we shall have a rubbing sound; and lastly, if pus be poured out, it will be determined not only by the greater space in which the heart moves, but by the sudden collapse and rapid sinking of the patient.

The duration of this secondary affection is very various. If the disease be severe and neglected, the patient often dies in three or four days; under proper treatment it seldom continues beyond a week; but there are cases in which, either from relapse or other cause, it lasts for three weeks, or even a month, as in an instance now in St. Thomas's. If this attack be altogether neglected, and the patient survive, the pericardium either becomes adherent, or the valves of the heart become permanently diseased, and its ulterior effects are dropsies, asthma, or affections of the lungs, which baffle all the resources of our art, and consequently are among the most fatal maladies incident to humanity.

The rheumatic inflammation in a much smaller number of cases affects the membranes of the brain. In these cases the patient first complains of severe headache, and this is shortly followed by delirium, high fever, and rapid pulse, and in this state he may die in a few days, but more commonly he recovers. As the opportunities of examining those who have fallen from rheumatic metastasis to the head are few, it is perhaps our duty to give the results in three cases which occurred in the extensive practice of Dr. Watson. The first was a young woman, 17 years of age, who had acute rheumatism of the joints; afterwards a rheumatic metastasis to the chest, for which she was bled, when she became furiously maniacal and died. The vessels of the brain were fuller than usual, but its membranes were healthy. The pericardium was glued to the heart in several places, and where not adherent, was universally coated with a layer of rough reticulated lymph. In another case, a post-boy, aged 28, attacked with much fever, and rheumatic pains shifting from joint to joint, but without any swelling; a metastasis at length took place to the brain, when he rambled, refused his medicines, and after lying delirious for 10 days, he died. On examination the cerebral veins were gorged with blood; a considerable quantity of serous fluid was found beneath the arachnoid and

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in the lateral ventricles, while the mitral valve was covered with a row of bead-like warts. The other two cases are not dissimilar. Dr. Watson, from a consideration of these cases, is inclined to infer that the delirium is not a metastasis of the rheumatic virus to the brain, but a symptom merely of pericarditis; but this hypothesis can hardly be maintained, pericarditis being often met without any delirium or affection of the brain, while rheumatic affection of the brain has been met with without the existence of any pericarditis. The pathological phenomena, however, of the first case may render it doubtful whether the virus had caused mere deranged function of the functions of the brain, or whether the substance of the brain, from the increased quantity of blood, was diffusedly inflamed.

Chronic Rheumatism is generally a strictly local disease, without fever or any considerable derangement of the health; and the symptoms, consequently, when it occurs in the joints, are limited almost entirely to pain and to the different appearances caused by the effusion into the internal or external parts of the joint. In many cases, however, as in affections of the hip or shoulder-joint, there is no swelling, and pain is often wanting, except when the part is put into action, or when the patient gets warm in bed. It has been shown that chronic rheumatism more often attacks two similar joints than one, giving a symmetrical character to the disease; and very commonly both hands, both wrists, or both knees are affected, and with identically the same lesion and deformity. The larger joints, however, are exceptions to this rule, for it is rare that more than one hip, one shoulder, or elbow-joint, is affected.

Besides the joints, the different muscles of the body, their fascia, or tendons, are often the seat of chronic rheumatism, and there are few structures of this kind that entirely escape. The scalp, for instance, is often affected. The muscles of the eye are occasionally so; Stoll quotes one case in which the woman squinted while the disease lasted. Rheumatism of the face is by no means unfrequent, and the muscles of the larynx are occasionally affected, causing aphonia. Everybody is familiar with the rheumatic affection termed "crick in the neck;" it also affects the articulations of the clavicle and the intercostal muscles. Rheumatism of the abdominal muscles is by no means rare, the principal pain being at their insertion into the crista of the ilium. Lumbago is well known as an affection of the lumbar muscles, extending often to the ligaments of the sacrum. The insertion of the tendo Achillis into the os calcis is another seat of rheumatism, but no parts are more often or more painfully affected than the tendinous structure of the soles of the feet. These forms of rheumatism are seldom accompanied by any swelling or other external symptom.

The pain in chronic rheumatism is often latent, unless the part be moved, and then the agony is severe. In many cases it is quiescent during the day, but is extremely acute during the night. This pain has a great tendency to shift from joint to joint, often subsiding and again recurring. Redness is rarely or never present in chronic rheumatism.

The lesions of motion vary from mere stiffness to an entire binding down of the joint. In this manner the hip and shoulder may be so firmly fixed, that the arm cannot be extended or the leg raised. The knee and elbow joints are generally semi-flexed, and cannot be straightened; while the fingers, if straightened, cannot be bent, or if bent cannot be straightened. When the joint is fixed, the muscles of the limb often become atrophied, sometimes partially so. In a case now in St. Thomas's, the flexors of one hand are so feeble, and the extensors so powerful, that the fingers are turned backwards; while, in the other hand, the muscles being in an opposite state, the fingers of the other hand are clenched, the nails almost growing like those of a Hindoo devotee into the palm. The duration of chronic rheumatism is extremely uncertain; it sometimes disappears in a few hours or in a few days, but it may last many weeks or months, or even years.

Chomel has attempted to give the relative frequency with which different parts of the body are attacked with chronic rheumatism, and out of ninety cases he found the muscles of the body were affected eleven times; one side three times; the upper limbs twelve times; the lower limbs twenty-two times; the trunk eleven times; the vertebral column nine times; and some part of the trunk or limbs twenty-two times.

*Diagnosis.*—The only disease with which acute rheumatism, when attended with swelling and redness, can be confounded, is, perhaps, erysipelas. Chronic rheumatism is also often of difficult diagnosis when it attacks the intercostal spaces, being often confounded with leucorrhœal pains, or affection of the chest. It may also be confounded with many neuralgic affections, as well as with pleuritic diseases of the bones.

*Prognosis.*—The number of deaths from acute rheumatism returned for England and Wales hardly exceeds one thousand; whence it is manifest that this disease is seldom fatal, and perhaps the number of unsuccessful cases hardly exceeds one or two per cent. But although this disease is rarely immediately fatal, yet a considerable number of persons ultimately fall from diseases of the heart, apparently resulting from the action of the rheumatic virus. A very few deaths occur from chronic rheumatism, so that the numbers that fall bear but a very small proportion to those that recover.

*Treatment.*—Acute rheumatism is manifestly a highly inflammatory disease, the parts being red and swollen, and the blood drawn presenting a more copious layer of 'buff' than most other diseases, the proportion of fibrin, according to Andral, amounting sometimes to nine or more; we can hardly feel surprised that bleeding has been largely had recourse to. But, although bleeding has been extensively adopted, the profession is much divided as to the advantage derived from the practice.

Sydenham attempted the cure of acute rheumatism by bleeding, and he took ten ounces of blood on the first day, as much on the second, and he bled a third time a day or two afterwards, and three or four days after this he bled a fourth time. This was the early practice of our great master, but some years later we find he bled less and purged more, observing that repeated bleeding was too debilitating. This, however, is not the fullest extent to which bleeding has been carried, for Sauvage says that at Montpellier they bled in his time thrice a day, and to a great amount, and the result of his experience was that nature was the best physician. Bouillaud is perhaps the only modern physician who has adopted the system pursued at Montpellier; for in cases of no great severity he recommends four pounds and a half of blood to be taken in twenty-four hours, while in graver cases he takes eight, nine, and ten pounds of blood within the week. The advantages of this mode

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of practice, he affirms, are, that the disease does not become chronic, and that its duration is abridged from one to two weeks, the mean duration of his cases, reckoning from the time of their admission to the hospital being nineteen and a-half days. The objections to this practice are, first, that very little is gained as to time; again, that the loss of so large a quantity of blood is worse than the disease, for it would be felt by most persons all their lives; and lastly, that this mode of treatment appears to have caused in his practice an unusually large number of cases of carditis—a larger number, indeed, than has been witnessed by any other person in the profession.

Without entering upon the effects resulting from those who adopt a middle course, it may be stated that many practitioners in the present day hold that bleeding, while the inflammation is confined to the joints, neither shortens the disease nor renders it more bearable, and therefore, except in particular cases, they adopt a treatment almost exclusively by purgatives and opiates. The particular purgative perhaps is not of great moment, but at St. Thomas's Hospital, a drachm of the sulphate of magnesia, with ♏ xv. of the tinct. hyoscyami, out of camphor mixture, every four or every six hours, has been found eminently efficient and a perfectly safe remedy. Its effects are to moderately purge the patient, and to assuage his pains, and about the tenth day, or shortly afterwards, all the symptoms abate; in the third week he is generally up, in the fourth week, he is for the most part well, and, except in a few cases, in which the articulations of the hand remain enlarged, and which are reduced by a few leeches, no bleeding need be had recourse to.

Under the purgative treatment, carditis and arachnitis are of rare occurrence, but in a very few cases they do occur, and the treatment is similar in both instances. Some blood, but not to a large amount, should be taken from the head in the one case, and from the chest in the other; this done, calomel should be given to affect the mouth, in doses of five grains, once or twice a day, or every six, or every four hours, according to the severity of the symptoms, and it almost uniformly happens that, when ptyalism is produced, the heart and the brain are immediately relieved. It is remarkable that mercury, although it appears the specific agent in rheumatic carditis or arachnitis, has no very marked beneficial effect in the purely articular forms of acute rheumatism, which is another analogy bringing this disease under the laws of morbid poisons.

There are a small number of feeble irritable patients, who suffer so severely from the pains of acute rheumatism that their minds wander, or they become hysterical; and in these cases small doses of opium, gr. ſs. to gr. j., every six hours, is the best treatment.

Antimony is a remedy which has been much praised in the treatment of acute rheumatism, and perfectly succeeds in a few cases, in moderate doses; more frequently perhaps it is given without any marked success. Bouillaud says, he has seen the antimonium potassio-tartarizatum given to the extent of 150 to 160 grains in ten days, but that its efficacy was not greater than in the ordinary mode of small doses, while it often disagreed and produced derangement of the digestive organs.

The treatment of chronic rheumatism varies, according to Dr. Macleod, as it assumes one of the five different forms he assigns to it, or according to the tissue it affects; but rheumatism scarcely admits of a strict analysis into tissues, and perhaps the more practical rule is, that the treatment varies according to the joint affected. If the shoulder-joint be the part diseased, potassii iodidi, gr. viij. out of camphor mixture, ter die is generally efficient, especially if assisted by a blister. The elbow-joint yields even with more certainty to the same treatment, and often without the blister. The wrist and small joints of the hand, yield to the neutral salts, as the sulphates of soda or magnesia; but, if very chronic and constitutional, perhaps more often to turpentine, as olei terebinthinæ, ♏ x. to ʒ j., ter die, or to grains x. of the Canadian balsam, three times a day.

If the hip-joint be affected, and the disease is very acute, it is best treated by the disulphate of quina, gr. v. 6ᵗᵃ vel 4ᵗᵃ horis; if this disorder be only slightly acute, the warm bath, with small doses of mercury, or of potassium iodidum, succeed best, and if these fail cupping and blisters may be recommended, but they do not often greatly relieve the patient. If the knee be affected, mercury, leeches, and poultices, or else cold lotions, are the best remedies; but this latter disease is often long protracted and of difficult cure, whatever means we may adopt. Of all the effects of chronic rheumatism, however, the affections of the ankle joint are the most intractable, and no treatment can be spoken of with confidence; but, take it altogether, the turpentines are the most successful remedies. In cases of lumbago, if the disease does not yield to purging, it very rarely resists cupping on the loins; and if that fails ʒ ſs. of sp. terebinthinæ twice a week may be tried.

There is one remedy possessed of great fame in the cure both of acute and chronic rheumatism,—or colchicum; and Dr. Macleod speaks of it almost as a specific in diseases of the capsular membrane. In many well-marked diseases of this class, however, it has eminently failed, and after an extensive trial, we conceive it has not been found more beneficial than the more simple purgatives, while to some constitutions it seems eminently pernicious.

In chronic rheumatism much local treatment has been employed, but hitherto without any very satisfactory result; the warm bath seldom affords relief. Dr. Gower introduced the practice of wrapping the patient up in oiled silk, and applying heat by means of a spirit lamp, but this treatment was attended with little success. At the present moment wrapping the affected part in cotton wool, and then wrapping it up in oiled silk, is practised, and it is supposed with more success; while, among non-professional practitioners, an extensive series of experiments of wrapping the patient up in a cold wet sheet, and applying heat by means of a feather bed, &c., is going on, but with a success still problematical.

The diet of the patient, in acute rheumatism, should be strictly limited to slops and light puddings, and even in many chronic cases it is desirable it should be confined for a short time to puddings and white fish.

### Of Podagra (πους a foot, and αγρα seizure, arthritis from αρθρος a joint. Gout).

Gout is an inflammation affecting the same tissues as rheumatism, and is likewise marked by the same mobility from part to part, and has also the same want of tendency to ulceration. It differs from Rheumatism, however, in the disposition of the inflamed parts to deposit a singular substance, or the urate of soda, and



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also in its tendency to affect the stomach, the alimentary canal, and the bladder, rather than the heart and head. The common appellation, gout, is derived from the French *goutte*, a drop, and springs from the same physiology as gave rise to the origin of the term rheumatism. 215 cases are said to have died of this disease in England and Wales in 1839.

*Remote Cause.*—Two theories have been imagined to explain the remote causes of gout. The one is, that it results from general causes, as atmospheric vicissitudes, errors in diet, &c., "podagra Bacchi Venerisque filia," is a received maxim, and, according to Sydenham, it occurs chiefly in those who have passed their lives in ease, voluptuousness, and high living. The other is suggested by Rostan, who, observing the many different limbs it simultaneously affects, its rapid transition from joint to joint, and its singular deposition of the urate of soda, concludes that there is something more in gout than mere simple inflammation occurring in a particular diathesis, and he hints at a specific cause, having probably its seat in the solids. Sydenham, it is well known, considered the cause to be a peccant state of the fluids.

*Predisposing Causes.*—A few children have been attacked with gout at the early age of seven years: it very rarely, however, occurs before puberty, but is seen in both sexes under 20. Many cases occur between 20 and 30, but the period of greatest liability is perhaps from 30 to 50. After this the chances of exemption increase with age, probably from the more temperate habits of advanced life. At whatever age, however, gout appears, every attack establishes a greater disposition to another. Women often suffer greatly from gout, but not in an equal degree with men.

It is generally supposed that gout is hereditary; and in many instances it is so, whether the party adopt the habits of intemperance of his ancestors, or whether he be abstemious in his mode of living. In some families it attacks only alternate generations, following the law of *atavism*. Sydenham sums up the predisposing causes by saying, that it destroys "more rich than poor, and more wise men than fools."

*Pathology.*—The theory of gout is similar to that of rheumatism; or the gouty virus may produce either *neurotic* pains or else *inflammation*, and in either of these forms has the same tendency to affect similar limbs and similar joints, and also to fly from one part to another with terrific violence. This erratic property of gout is so well known, that Gay has thus popularly described it:—

> "Next gout appears, with limping pace,
> Pleads how he shifts from place to place;
> From head to foot how swift he flies,
> And every joint and sinew plies;
> Still working when he seems supprest,—
> A most tenacious, stubborn guest."

When the gout assumes an inflammatory character, it produces all the forms of articular inflammation which have been described in rheumatism, and these inflammations attack nearly the same parts, as the bones, cartilages, synovial membranes, bursæ, ligaments, muscles, tendons, and aponeuroses. These inflammations have nothing to distinguish them from rheumatism, except the singular pathological phenomenon of a tendency to the deposition of the urate of soda, a discovery we owe to the late Dr. Wollaston.

It is not determined in what form of inflammation the urate of soda is most frequently deposited, but occasionally it appears to be nearly the sole secretion from the affected part, nothing being seen on the poultice but this salt in a more or less fluid state. It is equally secreted from the joints of the toes or fingers, and probably from all their different tissues. Portal gives a case in which the articulations of both hands presented deposits of urate of soda, both within the capsules of the joints, and externally among the ligaments, while the tendons of the extensor muscles of the fingers were almost destroyed. In the Hunterian Museum of Glasgow there is a finger from a gouty hand, with a joint opened and bent upon itself, showing not only a deposition of the salt, but an erosion of the cartilages; also another in which the joint is full of this peculiar secretion, and a third in which the joint is everywhere invested with it. In the Museum of St. Thomas's Hospital there is a specimen in which the femoral cartilage of the knee-joint is coated with it, as if smeared over with plaster of Paris; and another in which it is deposited on the ligaments of the extensors of the hand. Guibert gives a case in which the metatarsal articulation of the great toe was surrounded by urate of soda of a rose tint, and on the inside of the foot, in the cellular tissue, was an abscess containing urate of soda, making its way to the surface; on opening the joint the same substance was also found, and on cutting through the tendons, pieces of urate of soda were distinctly seen between the fibres. Simon gives an account of a gouty skeleton, of which the bones were so completely anchylosed that even the brazen skeleton dedicated to Hippocrates in the temple of Delphos could not have been more inflexible. The bones, also, affected with this disease have been found swollen, and sometimes so soft as to have been easily cut by the scalpel.

The urate of soda is deposited first in a white fluid state, like a mixture of chalk and water, and often in such quantities that a poultice, though applied several times a day, has been covered with it, and that for several days together. It afterwards hardens and forms what, from their colour and appearance, have been termed *chalk-stones*, often superficial and of considerable size, so that when the skin has ulcerated a patient has been said in one case to have scored his game of cribbage with his knuckle, and in another to have written on the table with the *chalk* penetrating through the ulcerated tips of his fingers.

The arteries are often found ossified in gouty persons, and especially the coronary arteries of the heart; bony matter also has been often found deposited on the valves, and around the orifices of the heart, and hence the tendency of gouty patients to apoplexy and to asthma. The appearances which exist when a patient has fallen from gout of the stomach, bladder, or intestinal canal, have not as yet been described.

*Symptoms.*—The symptoms of the gout vary according as it attacks the joints, the stomach, or the intestinal canal, but the proportionate frequency with which these different parts are attacked is not yet ascertained. It may be acute or chronic, and when the viscera are affected, it has been termed irregular, retrocedent, or misplaced. Sydenham was himself a great sufferer from this affection, and laboured under it for more than 34 years, and thus describes an acute attack or fit.

"It comes on a sudden towards the close of January or beginning of February, giving scarce any sign of its approach, except that the patient has been afflicted for some weeks before with a bad digestion, crudities of the

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stomach, and much flatulency and heaviness, which gradually increase till at length the fit begins." "The patient goes to bed, and sleeps quietly till about two in the morning, when he is awakened by a pain, which usually seizes the great toe, but sometimes the heel, the calf of the leg, or the ankle. The pain resembles that of a dislocated bone, and is attended with a sensation as if water just warm were poured upon the membranes, and these symptoms are immediately succeeded by a chilliness, shivering, and slight fever. The chilliness and shivering abate in proportion as the pain increases, which is mild in the beginning, but gradually grows more violent every hour, and comes to its height towards evening, adapting itself to the numerous bones of the tarsus and metatarsus, the ligaments whereof it affects so as sometimes to resemble a tension or laceration of those ligaments, sometimes the gnawing of a dog, and sometimes a weight and coarctation or contraction of the membranes of the parts affected, which become so exquisitely painful as not to endure the weight of the clothes, nor the shaking of the room from a person walking quickly therein; and hence the night is not only passed in pain, but likewise with a restless removal of the part affected from one place to another, and a continual change of its posture. Nor does the perpetual restlessness of the whole body, which always accompanies the fit, especially in the beginning, fall short of the agitation of the gouty limb. Hence numberless fruitless endeavours are used to ease the pain by continually changing the situation of the body and the part affected, which notwithstanding abates not till two or three in the morning, that is, till after 24 hours from the first approach of the fit." "And being now in a breathing sweat he falls asleep, and upon waking finds the pain much abated, and the part affected to be swelled; whereas before only a remarkable swelling of the veins thereof appeared, as is usual in all gouty fits."

"The next day, or perhaps two or three days afterwards, the part affected will be somewhat pained, and the pain increase towards evening, and remit towards break of day;" and "what we call a fit of the gout is made up of a number of these small fits; at length the patient recovers, which, in strong constitutions and such as seldom have the gout, often happens in fourteen days, and in the aged, and in those who have frequent returns of the disease, in two months; but in such as are more debilitated either with age, or the long duration of the distemper, it does not go off till summer advances."

In aggravated cases it attacks both feet, the hands, wrists, elbows, knees, and other parts; sometimes bending the fingers crooked and motionless, and at length "form stony concretions in the ligaments of the joints, which destroying both the scarf-skin and the skin of the joints, stones not unlike chalk, or crabs' eyes, come in sight, and may be picked out with a needle. Sometimes the morbific matter is thrown upon the elbows, and occasions a whitish swelling almost as big as an egg."

"During the first fourteen days the urine is high coloured, and after separation lets fall a kind of red gravelly sediment, and not above a third part of the fluids taken is voided by urine, and the body is generally constipated during this time. The fit is accompanied throughout with loss of appetite and chilliness of the whole body towards the evening." When the fit is going off a violent itching seizes the foot, especially between the toes, and the skin peels off as if the patient had taken poison.

When the disease has become chronic, or, as Sydenham terms it, inveterate, "after yawning, especially in the morning, the ligaments of the bones of the metatarsus are violently stretched, and seem to be squeezed with great force with a strong hand. And sometimes, though no yawning has preceded, when the patient has disposed himself to sleep, he feels a blow on a sudden as if the metatarsus were breaking in pieces by a large stick, so that he wakes crying out with pain. The tendons of the muscles of the tibiæ are sometimes seized with so sharp and violent a convulsion or cramp, that if the pain it occasions were to last only a short time, it could not be borne with patience."

After many racking pains, the following paroxysms become less painful, when, "instead of the usual external pain, a certain sickness, a pain in the belly, a spontaneous lassitude, and sometimes a tendency to diarrhœa succeeds." Besides the pain and sickness, the patient becomes lame and almost incapable of motion, and, like the late Sir Joseph Banks, is perhaps obliged to be wheeled or carried from room to room. The patient is not only reduced to this helpless condition, but, to complete his misery, his mind sympathizes with his body." "For every paroxysm may be justly termed a fit of anger, the rational faculties being so enervated by the weakness of the body as to be disordered on every trifling occasion, whence the patient becomes as troublesome to others as he is to himself.

Another form of chronic gout is *atonic gout*, or when the joints enlarge and the tissues and ligaments become thickened, and the seat of various effusions, so as often to distend and even to dislocate the bones, and yet if the patient be kept quiet he suffers no pain. The general symptoms, however, are most distressing, the patient suffering from loss of appetite, indigestion, sickness, nausea, flatulence, acid eructations, pains of the stomach, cramps in the legs, and in various parts of the body; also great dejection of spirits, vertigo, palpitation, fainting, asthma, and perhaps from stone or gravel, and these perhaps continue with occasional intervals during the remaining life of the patient, who is satisfied he has the gout *flying* about him, and that he should be well if he had a regular fit.

In the course of this disease there may be a metastasis to the stomach or other part, and the affection is now termed *retrocedent* gout, the pain in the joints being trifling, or having entirely subsided. When the metastasis is to the stomach or intestines, it may be either of a spasmodic or inflammatory character. The spasmodic is the most frequent, and in this case the patient is seized with violent pains in the stomach, with great faintness, coldness of the extremities, and a quick, small, and scarcely perceptible pulse, accompanied with much flatulence, acidity, or vomiting. If, on the contrary, the attack be of an inflammatory character, the pain is perhaps equally great, but is increased on pressure, and there is more re-action, some fever, a fuller pulse, with vomiting, and perhaps obstinate constipation. The duration of these attacks is short, as the patient must be quickly relieved, or quickly perish. Besides metastasis to the stomach and intestines, this retrocedence may take place to other parts, as to the testicle, bladder, rectum, or to the head, and in the latter case the patient may die apoplectic. The transition of the gouty virus is often marked by a pain shooting along the nerve as sudden and as rapid as a galvanic shock, and so violent as to have been compared



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to stabbing with a knife. Gout also, besides being transferred from part to part, often alternates with asthma, so that when the patient is free from the one disease he labours under the other.

But the miseries of the gout do not end here; for Sydenham says, "I made bloody urine, and did so whenever I walked much, or was carried in a coach over the stones, though the horses went slowly. The urine I voided on these occasions, though it looked very bad at the time of making, so as to resemble pure blood, yet soon after it became clear at the top like natural urine, the blood falling to the bottom by itself in clots." A description which renders it probable that his urine was loaded not only with blood, but also with uric acid.

*Diagnosis.*—The diagnosis between gout and rheumatism is often exceedingly difficult, so much so that nosologists have given a mixed class, or rheumatic gout. Mr. Hunter warmly opposed this compound appellation, for in his opinion no two distinct diseases, or even distinct diatheses, can co-exist in the same constitution; a law, it must be admitted, to have many exceptions.

*Prognosis.*—Every assurance office objects to a gouty person as liable to a disease indicative of excessive indulgence in the pleasures of the table; or at least to a disease tending to shorten life, from the wear and tear it occasions of the constitution; and the objection is unquestionably founded; for although a few persons may reach advanced age notwithstanding its repeated attacks, yet many fall prematurely from this affection, or from the asthma, affection of the heart, apoplexy, or from the accidents that helplessness and debility render the patient liable to.

*Treatment.*—The gout consisting essentially in inflammation of the joints and their surrounding tissues, it might be supposed that this disease would be best treated by bleeding, and blood has been drawn to a considerable extent, but without any corresponding benefit. "Bleeding," says Sydenham, "is not to be used either by way of preventing an approaching or easing a present fit, especially in the aged, for, though the blood that is taken away resembles pleuritic or rheumatic blood, yet bleeding is found to do as much mischief in this as it does good in those;" "and bleeding in the interval, though long after the paroxysm, is found to occasion a fresh fit." The experience of Barthez, of Guibert, and Hallé entirely coincides with that of Sydenham, for however freely employed (and in some instances 70 ounces have been taken away in a few days), they say bleeding does not afford that relief to to the local pain and inflammation which might have been expected, while the restlessness, debility, and mental depression, are often rendered truly distressing. In the present day bleeding is generally restricted to two cases,—or leeches to the part where the inflammation rises so high, or is so chronic, as to threaten the patient with the permanent loss of the use of some joint; and also to cases of inflammatory metastasis to the stomach or other internal organ, when leeches are absolutely necessary.

Sydenham was as great an enemy to purging as he was to bleeding; and he says, "I am abundantly convinced, from much experience, that purging either with mild or strong catharties, whether it be used during the fit, or in its declension, or in a perfect intermission, or healthy state," "endangers the life of the patient by hurrying on to the viscera, which were quite safe before." The objection taken by Sydenham to purgatives lies certainly against those in use in his day, and which were of the most drastic kind. But it may be laid down as a rule that the class of neutral salts are not only safe, but efficient in relieving, though perhaps not of curing, gout. The theory on which they are prescribed is, that the alkaline base of the neutral salt is absorbed, and combines with the insoluble urates deposited in the joints, forming a soluble sub-urate, which can readily be absorbed; and again, more alkali being sent to the kidney, that organ is now enabled to remove more uric acid, in a soluble state, from the system than under ordinary circumstances. The salts the most in use are the sulphates of magnesia or of soda, and especially the former, and half a drachm to a drachm should be given every eight, six, or four hours, according to the state of the bowels, and the acuteness of the symptoms. It is also necessary to give some relief to the patient from his excessive suffering, and an opiate should be added, as the tinct. of hyoscyami, syrup of poppies, or some preparation of opium. This method relieves the patient and shortens the paroxysm; but when the relief is complete it should be abandoned, for sometimes the gout will return even under its use.

Colchicum or meadow-saffron was introduced as a specific in gout; and the "eau médicinale," as long as it was a novelty, and acted upon the imagination, occasionally shortened or removed the paroxysm as by a charm. A more widely-extended experience, however, has shown it to have little influence over the disease while in some instances it has been followed by most alarming consequences, acting upon the stomach and bowels with all the virulence of an active poison. It is still however used, and is valuable for its purgative qualities, although not for its specific effects, and may be given as an extract or tincture, or as a wine combined with some form of saline draught.

Mercury, from its power of absorbing many periosteal nodes, has been often employed with a view of removing the deposits of urate of soda, or the chalk-stones; but experience has shown this to be dangerous practice, for, if pushed to any extent, not only have the chalk-stones not been removed, but in two cases the patient has appeared to have fallen in consequence.

If acute gout should have retroceded, and the stomach or intestinal canal be inflamed, leeches should be applied to the abdomen or epigastrium, followed by a poultice, while the internal remedies should be the neutral salts with the tinct. hyoscyami 6[m] vel 4[m], and it is very rare that more active medicines are necessary.

In chronic gout the treatment by saline purgatives and opiates is the same; but in *atonic* gout some light tonic medicine may be added, as 5 to 10 grains of the citrate of iron, or a drachm of the tinct. aurantii, and the menstruum may be the aqua menthæ pip. or the infusum aurantii comp. A large number of these cases, however, though the general health is improved by this treatment, are often altogether unrelieved, as to the local symptoms, and are often quite unable to assist themselves. In these instances the turpentines appear to be beneficial, as spruce beer, or the Canadian balsam, gr. v. to x. ter die, or the olei terebinthinæ ʒ j. out of an effervescing draught once or twice a day. Sydenham's method, or by manna, may also be tried.

If the chronic or *atonic* gout should become retrocedent, and the stomach and intestinal canal be the seat of the spasmodic form of the disease, Sydenham strongly recommends laudanum should be exhibited;

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but perhaps the following draught is more efficacious: mist. camphoræ ℥ x., sp. ætheris sulphuriei comp. ℨ j., confectio opiata ℨ ſs., tinct. cardamomi ℨ j., and perhaps half a drachm of the sulphate of magnesia, to remove from the stomach any undigested matter which may remain as an irritating cause. This should be given every hour till the patient is relieved; and while it is being prepared, hot brandy and water should be freely administered, and hot cloths applied to the abdomen, as well as hot bottles to the feet.

Sydenham recommends, from experience in his own case, large doses of manna in all cases of what he terms "bloody urine."

With respect to any local treatment during the fit, Sydenham says, "if outward applications be inquired after to ease the pain of the gout, I know of none, though I have tried abundance both on myself and others, and I have laid aside the use of topics for many years." It is generally admitted that cold is dangerous, while warmth is productive of little relief. In some instances the urate of soda is deposited in such abundance that the skin ulcerates, and the salt is discharged in considerable abundance in a fluid state. It might appear the right practice to apply a poultice and encourage the discharge, in order that by its entire removal the joint might be saved. This, however, is very dangerous practice, for the discharge is so debilitating that two patients appeared to have died from this mode of treatment. It is much safer to wait till the chalkstone is concreted, and then operate for its removal. With respect to the use of cold water, the practice is as old as Harvey, and subsequently it has been adopted and abandoned by many practitioners. Dr. Parry had at one time two cases who had attempted to cut short the fit by plunging their feet in cold water. The relief was instant, but in a few hours both were dead of apoplexy. The recent fatal result of this remedy in Sir Francis Burdett's case will not soon be forgotten.

As diet appears to have a great influence in the production of gout, so we should imagine it should have great influence in its removal; and, during the fit, it should be slops and light puddings, and afterwards white fish, till the paroxysm has terminated. This disease is so distressing that many persons are inclined severely to diet themselves during the interval. Sydenham says that a milk diet, or drinking milk as it comes from the cow, or boiled without adding anything to it, except perhaps a piece of bread once a day, had been much used for twenty years past in his time, and done much service in abundance of gouty patients. But on quitting it and returning to the mildest and tenderest diet of other persons the gout has immediately revived; and he adds, many cannot bear this regimen. An entirely water regimen he considers hurtful. His recommendations are, that we should be early to bed, keep the mind free from all disquietude, live with the greatest moderation, clothe ourselves warm, and ride on horseback. One other point with regard to treating the patient during the fit, is, if it be necessary to move him either on account of his restlessness or other cause, that this be done with great care and tenderness by the attendants; for although the pain may be latent while the parts are quiet, yet the least shock often causes the most excruciating agony.

The irritable state of mind of the patient during the paroxysm has been mentioned; and it is well known that slight moral causes will often produce a fit, while powerful emotions have sometimes cured one. There are many instances of persons confined to their beds with gout starting up and running away on an alarm of "fire" being raised. Dr. Rush gives the case of an old person whose son by some accident drove the shaft of his waggon through the window of the room where he was lying, when, forgetting his crutches, he leapt out of bed, and was found by his wife angrily walking up and down the room.

It is quite essential, therefore, the minds of gouty patients should be kept as tranquil as possible.

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Order III.—Of Tuberculoma.—(*Tuberculum*, a small tumor. Scrofula.)

Tuberculoma is a peculiar morbid substance or growth infesting every organ and tissue of the body, and more especially the lungs, causing phthisis or consumption; but, wherever found, it follows, with little exception, the same laws in its development, course, and fatal termination. After inflammation this is the most important of the elementary forms of disease, both from the great number of persons it affects, as well as from its destructive tendency; for it is probable that every fourth or fifth death in England and Wales takes place from this disease having formed in some one or other organ or tissue of the body. Tuberculoma of the lungs, or phthisis, the more leading disease of this class, was unquestionably known to Hippocrates; but the laws of this substance, and the changes it undergoes, appear to have been first determined by Cruikshanks in 1790, and his opinions have been adopted and extended by Laënnec and Louis, so as to be generally received by most pathologists of the present day.

*Remote Causes.*—There is hardly any subject more interesting in medicine than the remote causes of tuberculoma. The broadest fact already established on this point is, that the domesticated animal is more liable to tubercular disease than the same animal in a wild state. The stabled cow, the penned sheep, the tame rabbit, the monkey, the caged lion, tiger, or elephant, are almost invariably cut off by tubercular affections. In man the same law appears to prevail, or in proportion as his habits of life are artificial so is his tendency to tubercular disease. This is strongly seen in the mining districts of Cornwall and Devonshire: for although those counties are considered among the most healthy portions of Great Britain, yet one-half of the whole number of the miners deprived of air and light die of phthisis. The Reports of the Registrar-General also show that, comparing the deaths from phthisis among the agriculturists and among the inhabitants of towns, the latter die in an increased ratio of 24 per cent. over the former; yet it is generally supposed that the dietary and general comforts of the townsman are greater than those of the countryman. Among the townsmen also it is determined that there are certain classes of men more predisposed to phthisis than others, as those workmen who suffer great vicissitudes of temperature, or who breathe an air loaded with particles of dust: as bakers, needle-grinders, gun-flint makers, cotton and wool carders, and bricklayers' labourers, and in this class of persons the disease has acquired the epithet of the "grinder's rot." It would appear also, from the great numbers that fall in the Foot Guards,

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compared with the population generally, that the night air must be greatly injurious. A more minute analysis of the numbers that die of phthisis in the different ranks and classes of life is greatly to be desired in illustration of the remote causes of phthisis. The late Professor Coleman was of opinion, that by confining the horse in a dark and dirty stable, and by feeding him on bad provender and neglecting to clean him, he could produce phthisis in that animal at will; and similar causes will probably be found to produce similar results in man. When, however, we consider how many persons there are who carry cleanliness to excess, whose diet is most studied, and whose every exercise is directed to health, and who nevertheless die of phthisis, it is plain that some more secret and hidden circumstance still remains to be discovered to account for the existence of tubercular disease in this country.

It has been supposed that the tendency to tubercular disease was limited by latitude,—that it never appeared to the south of the Mediterranean, and consequently that it must have a local origin. But this does not appear to be the case, for the returns of the army have shown, to the astonishment of everybody, that phthisis is more frequent in the West Indies than even in this country.

| Mortality by Phthisis Pulmonalis per 1000 White Troops. | Windward and Leeward Command. | Jamaica. | Gibraltar | Malta. | Ionian Islands. | Bermuda. | Canada. | Nova Scotia and New Brunswick. | Cape of Good Hope District. | Dragoon Guards, and Dragoons serving at Home. | Civil life in England and Wales, according to Registrar-General's Report. | Naval Force, Mediterranean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | $6\frac{3}{10}$ | 6 | 5 | $8\frac{2}{10}$ | $6\frac{4}{10}$ | 7 | $5\frac{3}{10}$ | $5\frac{3}{10}$ | 4 | |

It would appear, then, from these tables, that England and Wales were more exempt from phthisis than many countries which, from their higher temperature, have hitherto been supposed to enjoy a remarkable exemption from this complaint. Another unlooked-for result from these tables is the entire refutation of the hypothesis that paludal districts are in an eminent degree exempted from phthisis; since England and Wales, the Cape of Good Hope, Canada, and Malta, countries either the driest or the best drained, and consequently suffering the least from paludal diseases, are actually those countries the most free from phthisis. Another general deduction of the influence of climate is, that phthisis is most frequent in low and damp situations; while it is far less so in the mountainous districts of all countries. Again, in whatever climate the disease breaks out, it is the opinion of many pathologists that its course is most rapid if the patient remains in that country; thus the late Dr. Heonen's experience convinced him, that when the disease broke out among our troops on the shores of the Mediterranean, that no other chance remained of prolonging the patient's life than by sending him at once back to this country. It must be admitted, however, that this law is anything but proved.

To those who consider variations of temperature, and the vicissitudes of the weather generally, as the great causes of phthisis, it will appear remarkable that the number of deaths in each season from this disease is nearly equal. Thus, according to the Registrar-General's Report for the year 1839, of 21,827 deaths from phthisis 5600 took place in winter, 5778 in spring, 5501 in summer, and 5148 in autumn. The influence of temperature, however, over the disease, according to the idiosyncrasy of the patient, is remarkable: for many survive as long as the weather continues warm, and die as soon as it changes to cold, while others suffer only slightly as long as the weather is cold, but perish as soon as it becomes warm.

It being impossible to connect phthisis in the present state of medicine with any given cause, or series of causes, another mode of viewing it presents itself; and that is, looking to the peculiar course many cases of phthisis run, the consecutive diseases it sets up, as fatty liver and ulceration of the intestines,—diseases certainly not a consequence of mere debility,—whether it may not result from the action of a morbid poison, rather than from any combination of general causes? The most general conclusion perhaps we can come to is, that the agent, whatever it may be, is a depressant of vital action; and that whatever tends to lower the system, as profuse evacuations, excessive depletion, scanty diet, insufficient clothing, unhealthful situations, or depressing passions, may become the predisposing cause of this disease.

*Predisposing Causes.*—The tendency to the formation of tubercle is not equally great in all parts of the body, nor at all periods of life. Tubercle of the brain, the bones, and of the mesentery, is most common in infancy, childhood, and early adolescence. But tubercles of the lungs, which form so large a portion of all these affections, although they have been found in the fœtus, and at every period of life up to 80, yet it will be seen by the following tables from Bayle and Louis that it is most frequent between the ages of 20 and 40; or there died from phthisis from

| Years of Age. | Bayle. | Louis. | Total. |
|---|---|---|---|
| 15 to 20 . . . | 10 | 11 | 21 |
| 20 to 30 . . . | 23 | 39 | 62 |
| 30 to 40 . . . | 23 | 33 | 56 |
| 40 to 50 . . . | 21 | 23 | 44 |
| 50 to 60 . . . | 15 | 12 | 27 |
| 60 to 70 . . . | 8 | 5 | 13 |
| | 100 | 123 | 223 |

Of ages younger than 15 there died of this "canker of the bud," according to Papavoine, out of 408 children,

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| Age. | Died. | Age. | Died. |
|---|---|---|---|
| At 2 years or less | 72 | At 9 years . | 16 |
| 3 . . . . | 64 | 10 . . . | 18 |
| 4 . . . . | 46 | 11 . . . | 12 |
| 5 . . . . | 35 | 12 . . . | 24 |
| 6 . . . . | 32 | 13 . . . | 16 |
| 7 . . . . | 29 | 14 . . . | 11 |
| 8 . . . . | 24 | Age not noted . | 14 |
| | | | 413 |

*Sex* has some influence in the production of phthisis, but not to any great extent, for out of 118,584 cases that died in England and Wales in 1838-1839 of that disease, 56,041 were males, and 62,543 females.

Of either sex *form* appears to give a marked predisposition to phthisis, the narrow-chested high-shouldered person being much more commonly its victim than those possessed of a more broad and capacious chest. Still the best formed persons often fall from it. The softer tissues also give many indications of a tendency to this disease; and most physicians are agreed that a soft flaccid habit of body—a remarkable clearness of complexion and softness of the skin—an eye of unusual pearly lustre—the senses and mental powers unusually acute—and a tumid upper lip, are all threatening marks of liability to this class of disease. If form gives a predisposition to phthisis, we can hardly feel surprised, as form descends, that tuberculoma should be popularly considered to be *hereditary* and to run in families. Louis, however, affirms, that in one-tenth only was he able to trace any parental taint of the disease.

With respect to *social* position, it is well ascertained, and on an extensive scale, that although the upper classes often suffer from phthisis, as the "fairest apple hangs on the highest bough;" still that the probability of life is greatly reduced from a tendency to tubercular diseases (especially among the children) in the lower classes resident in towns, who die, according to Dr. Alison, in Scotch towns, in the enormous disproportion of 45 or 50 to 5 and even 3, as compared with the agriculturists and upper classes.

*Race* has an influence in the production of phthisis. In this country the tendency of the Creole and Negro to phthisis is notorious. Even in the West Indies the black races are by no means exempt from this disease, and according to Mr. Rufz, the Creoles are remarkable for dying of it in large numbers in Martinique. This is the more unlooked for because as children they live almost in the open air, bathe daily, or still more frequently, and are singularly cleanly in their persons. He remarks also that the women of Martinique suffer in a large proportion, and yet the use of corsets is unknown among them.

Among the predisposing causes, says Laënnec, of phthisis, I know of none more certain than the *depressing passions*, especially when they are profound and long indulged; and this perhaps is the cause of the greater prevalence of this disease in larger towns, where bad habits and bad conduct are more common, and often the cause of those bitter regrets which neither time nor consolation can assuage. He adds, I had under my own eyes for ten years a most striking example of the influence of melancholy in the production of phthisis. There existed in Paris for that space of time a nunnery of a new foundation, and which had not been able to obtain from the ecclesiastical authorities anything but a temporary tolerance on account of the severity of its rules. Their alimentary regimen, although extremely severe, was still not beyond the powers of nature; but the spirit of their rules directing their minds to the most terrible truths of religion, as well as compelling them to resign themselves in everything to the will of the abbess, produced effects as sad as unexpected. These effects were the same in all. At the end of two months' sojourn in this house their menses were suppressed, and in a month or two afterwards symptoms of phthisis appeared. As they had not been allowed to take the usual vows, I intreated, as soon as this was the case, that they would leave the house, and all who followed this advice recovered. But during the ten years I was physician to this establishment, the members were renewed twice or thrice, with the exception of the superior, the tourière, the sisters who had the care of the garden, of the kitchen, and of the infirmary, or of such as had more frequent intercourse with the city, and consequently greater distraction. The rest died of phthisis.

*Pathology.*—Mr. Cruikshanks, in the year 1790, affirmed that tubercular matter had three stages, or that when first deposited in the lung it is a grey semi-transparent substance; that in a subsequent stage it becomes yellow, opaque, and hard, like particles of cheese; while, in a third stage, it melts down into common pus. These three stages are very generally received as marking the progress of tubercle, and its more detailed laws are as follow.

Tubercular matter, when first deposited, is a grey, semi-transparent, gelatiniform fluid—the fluid particles of which, after an uncertain time, are absorbed, so that the gelatiniform matter becomes hardened. It may be deposited in a variety of forms; that is, it may be granular or in large masses, or it may be infiltrated in an amorphous state into the loose substance of the lung, or deposited in a loose state at the free surface of a serous or mucous membrane. In the lungs, the granular form is the most frequent; and in this state the following changes may be plainly demonstrated. The gelatiniform granules are of a spherical shape, about the size of small shot, and often in such prodigious numbers that the broken or torn surface of the lung has a granular appearance, and hence they have been termed miliary granulations. The duration of this first gelatiniform stage is not determined, but after an uncertain period, as a few days, a few weeks, or a few months, a small opaque yellowish white spot is seen in the centre of each granule, and this increases from the centre to the circumference, till the whole granule is converted into an uniform opaque yellowish white matter of the consistence of cheese, and this is the form in which tubercular matter is most frequently met with, and is termed "crude tubercle."

The crude tubercle has been analyzed by Thenard, who determined it to consist of animal matter 98 parts, and of carbonate of lime, muriate of soda, and phosphate of lime, with a trace of oxyde of iron 1·85. But these proportions appear greatly to vary; for a tubercle having a cretaceous character consisted of animal matter only three parts, and of saline or cretaceous matter 96 parts. When viewed under a powerful microscope, crude tubercular matter has elementary forms which distinguish it from every other substance, and is thus described by Lebert It consists of molecular oval or circular glo-

bules, which vary from $\frac{1}{600}$ to $\frac{1}{300}$ of a Paris line in diameter, and are consequently much smaller than the blood globules. These are united by a transparent cellular tissue, forming cells, which, as the disease advances, disappears, and is supposed to have become atrophied. There are, besides, a number of angular corpuscles, $\frac{1}{180}$ to $\frac{1}{150}$ of a millimetre, irregular in form, and often containing a number of granules in their substance, which is yellow, opaline, and striated. It is these corpuscles which give to yellow tuberculoma its peculiar character.

The duration of the stage of crude tubercle is uncertain, but at length a third and last stage forms, marked by another vital process commencing in the centre of the granulation, by which the tubercular matter is softened and converted into pus, and from the centre this process extends to the circumference, till the whole tubercle is converted into pus. The tuberculous matter being thus liquified, ulceration of the surrounding tissues takes place, and the pus escapes as from an abscess.

The duration of the different stages of granular tubercle, it has been stated, is very various. It seems probable, from the short interval which elapses in some cases from the perfect health of the patient till his death from phthisis, that the whole duration of the disease hardly exceeds a month. In other cases, however, it is probable that each stage may last many weeks, or months, or years. Indeed, some patients appear to be dying of phthisis during a long life. As the granulations are frequently met with in every stage in the same lung, it is probable that the tubercular matter is often deposited in a succession of crops. Such are the laws of granular tubercle, as established by Cruikshanks. It must be admitted, however, that these laws, though generally are not universally received; for many pathologists, with Andral at their head, conceive that tubercle is always deposited in a crude state, and consequently that the grey gelatiniform matter and tubercle are distinct diseases. They admit that tubercular matter is often found within the gelatiniform matter, but esteem this an accident, the latter disease having supervened on the former. They admit also the central suppuration of the tubercle, but consider it to be caused by its including a portion of living cellular tissue, which takes on a suppurative action. Another circumstance, also, which has divided pathologists, is, whether tubercle is the result of inflammatory action. It is certain, however, that the tissues immediately surrounding both the granular and crude tubercle are often perfectly healthy in appearance, and that no redness or other vestige of disease is visible. It follows, therefore, if tubercle be a result of inflammation, it must be strictly of an achromatous character.

When tubercular matter is deposited in large round masses, it follows the same laws and course as granular tubercle. When, however, it is *infiltrated* into the substance of the lung, its changes are similar, but not so definite; for although the conversion of the gelatiniform mass into crude tubercle, and of crude tubercle into pus, begin in the interior of the infiltrated mass, yet these processes may be more or less superficial, and originate at any given point. Also, when deposited at the free surface of a serous membrane, it is generally found in a crude state, and so loosely attached that it may readily be wiped off; and whether it undergoes in this state any further conversion is undetermined. It is apprehended, however, that the vital changes which have been demonstrated taking place in the granular and larger formed masses distinctly prove this substance to be a living part, and subject to the laws of life. Some authorities have endeavoured to account for these changes by supposing some loose cellular tissue has become incorporated in the tubercular matter, and given rise to the changes in question; but this hypothesis hardly alters the case, as it still shows a living principle essentially connected with the tubercle. We shall now proceed to offer a few short remarks on the seat, size, and forms of tubercle.

When tubercular matter is deposited in definite masses, their *form* is round or ovoid; and as these forms are constant, it is evident this characteristic of their nature is not accidental, and almost demonstrates that it is first deposited in a fluid state.

The *size* of the tubercle is very various, or from a small granule to a hen's egg. In general, however, they vary in magnitude according to the organs in which they are situated. In the lungs they are seldom bigger than a swan-shot, although they have been met with as big as a pea, or even a hen's egg. In the spleen, they vary from a small shot to a large bean; while in the liver they are seldom less than an olive, and often as big as an orange. It is in the cervical, axillary, and inguinal regions, and also in the folds of the mesentery and mediastinum, that, according to Lugol, they attain their largest size, being often in these parts as large as an apricot, and sometimes greatly exceeding a large egg. These large tubercular masses, Lugol conceives, are often constituted of two or more tubercular tumors united; a formation sometimes rendered evident by incising the tumors, when we find the divisions distinctly marked.

Most pathologists conceive that the round tubercle is, for the most part, non-encysted—so much so that Louis states that he has only met with one case of encysted tubercle; but Lugol affirms that they are generally covered with an envelope.

The *seat* of tubercle is perhaps every tissue of the body; but, as a general rule, it has a decided predilection for cellular tissue. Dr. Carswell is of opinion, when the mucous system constitutes a part of the organ affected, that system is its principal seat.

The deposition of tubercular matter appears to be the result of a constitutional taint; for when a limb has been amputated in consequence of a scrofulous joint, the disease has, in general, broken out in some other joint or part. Again, notwithstanding the many phthisical bodies that are examined, and the many accidents incident to the examination, no instance is known of tuberculoma having been contagious. Tubercular matter likewise is not deposited with an equal frequency in all organs; neither are those organs which are the most frequent seat of tuberculoma in the child those organs in which it is most frequently found in the adult. Thus, out of 100 cases of tuberculated children, and 100 tuberculated cases of adults, M. Lombard found tubercles—

| | Children. | Adults. |
|---|---|---|
| In the Lungs . . . . . | 73 times | 100 times |
| Bronchial ganglia . . | 37 | 9 |
| Mesenteric ganglia . . | 31 | 19 |
| Spleen . . . . . . | 25 | 6 |
| Kidneys . . . . . . | 11 | 0 |
| Intestines. . . . . | 9 | 26 |
| Nervous centres . . . | 9 | 4 |
| Cervical ganglia . . . | 7 | 7 |

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| | | Children. | Adults. |
|---|---|---|---|
| In the | Meninges of the brain . | 6 | 2 |
| | Pancreas . . . . . | 5 | 0 |
| | Gastro-hepatic ganglia . | 5 | 0 |
| | Sub-peritoneal tissue . | 5 | 4 |
| | Inguinal glands . . . | 3 | 0 |
| | Sub-pleural cellular tissue | 2 | 0 |
| | Lumbar ganglia . . . | 1 | 4 |
| | Sub-mucous tissue of urinary bladder . . . | 1 | 1 |
| | Epiploon . . . . . | 1 | 1 |
| | Walls of the gall-bladder | 1 | 1 |
| | False membrane of the pleura | 1 | 2 |
| | Axillary ganglia . . . | 0 | 3 |
| | Ganglia of the anterior mediastinum . . . | 0 | 3 |
| | False membrane of the peritoneum . . . . | 0 | 2 |
| | Intercostal muscles . . | 0 | 2 |
| | Ovaries . . . . . | 0 | 2 |
| | Liver . . . . . . | 0 | 1 |
| | Cavity of the pleura . . | 0 | 1 |
| | Anterior mediastinum . | 0 | 1 |
| | Vertebræ. . . . . . | 0 | 1 |
| | Ribs . . . . . . | 0 | 1 |
| | Uterus . . . . . | 0 | 1 |
| | Prostate . . . . . | 0 | 1 |

Thus, it will be seen that tubercles of the spleen occurred in $\frac{1}{8}$th of the cases of children, and only in about $\frac{1}{18}$th in the adult. Again, tubercles of the intestines were found in only $\frac{1}{11}$th of the children, while in the adult they were met with in every fourth case. On the contrary, tubercle of the bronchial glands is much more common in the child than in the adult, or in the ratio of 4 to 1. It will be seen also that tubercles of the brain and meninges are more frequent in the child than in the adult, nearly in the ratio of 3 to 1. Tubercles of the lungs, it is admitted, are more frequent in the adult than in the child. Indeed the lungs are so constantly the great primary seat of tubercles, that Louis, after examining upwards of 350 adults that had fallen from phthisis, affirms it to be a *law* to which there are few exceptions, "that in the adult tubercles are never found in other parts of the body without the lung be also similarly affected." In the child, however, the exceptions to this law, according to Lombard, amount to one-third of the whole number of cases. Having thus stated the general laws of tubercle, it now remains to point out particular instances of this disease in the different organs and tissues.

Tubercles of the *brain* are often met with in children, and especially in those of a strumous constitution, between the ages of 1 and 12 years; after which they are rarely met with till after 20. In the child, the tubercular masses are most common in the hemispheres of the brain, and occupy indifferently the cortical and medullary substance, sometimes invading both. The cerebellum is also not unfrequently the seat of tubercle in children.

In the adult, tubercles of the brain are much less common than in children, and the parts situated above the centrum ovale are their most frequent seat. After those, the cerebellum, the meso-cephalon, the medulla oblongata, the spinal cord, the crura cerebri and cerebelli, the thalami opticorum, the corpora striata, the pituitary gland, and the commissura of the thalami,—instancing an order of liability to tubercle, says Andral, which by no means corresponds with that of inflammation or of ramollissement.

The tubercles found in the substance of the brain are generally few in *number*. In many instances we find but one; in others, two; and in no instance are they numerous. In *form*, they are generally globular; but although globular, occasionally their surface is unequal. In *size*, they vary from a small shot to a pullet's egg, and they have been met with still larger; the whole extent of one hemisphere of the brain or of the cerebellum having been either converted into a tubercular mass, or obliterated by its pressure.

Tubercles of the brain are often encysted. Gendrin affirms they are always so, and Léveillé is of the same opinion; the cyst is sometimes thin and adheres externally to the brain, while sometimes its internal surface sends processes into the heart of the tubercle. In other cases the membrane is of a remarkable thickness, fibrous, and even cartilaginous. The portion of the brain which surrounds the tubercle is often perfectly healthy; at other times it is congested, and at others in an almost diffluent state.

It is generally supposed that tubercles are first deposited in the brain in a fluid state, and that the aqueous portions are afterwards absorbed. After an uncertain time they undergo the process of softening, and pus is found at their centres. In a more advanced stage, the greater portion of the tubercles having been converted into pus, they have been mistaken for abscesses.

The spinal *cord* is also occasionally the seat of tubercles. A very beautiful specimen of this disease, situated in the lumbar portion, is to be found in the museum of St. Thomas's Hospital.

Besides the substance of the brain and cord being the seat of tubercles, their membranes are liable to this affection. Andral gives a case in which the anterior fifth of the pia mater covering the right hemisphere was studded with a great number of tubercles. Gendrin also gives another in which a softened tubercle was found between the dura mater and the arachnoid; and similar instances have been seen of tubercle existing between the rachidian dura mater and arachnoid, and also external to the rachidian dura mater.

### Of Tuberculoma of the Lungs, or Phthisis.

The deposition of tubercular matter in the *lungs* is termed *phthisis*. In the lungs the tubercular matter is secreted either as granules, or in larger masses, or it may be infiltrated into the substance of the lungs. We find it also in the grey semi-transparent state, converted into crude tubercle, and also transformed into pus. Each of these states may exist, *per se*, in the lung, but more commonly all these different states exist in the same lung and at the same time.

When death arises from the presence of the grey semi-transparent tubercle, the lung, on being torn, presents a granular surface, caused by the presence of myriads of miliary granulations, rather smaller but most resembling, except as to colour, the granules of boiled sago; while in other parts the tubercular matter is more fluid, less formed, and consequently infiltrated; and here and there may be met with granules undergoing the conversion into crude tubercle.

The patient more often falls in the second stage, or after the grey tubercular matter, or a considerable por-



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tion of it, has been converted into crude tubercle. In this stage the granular form has disappeared, so that the lung, at its most diseased portion, appears infiltrated with crude tubercular matter. It is in this stage also that we sometimes find the tubercle deposited in large circumscribed round masses as big as a nut, a walnut, or an egg.

When the patient falls in the last stage, or after the tubercular matter has ripened, softened, and been converted into pus, we find, if the lung contains the large crude round tubercle, that this process has begun in the centre, and proceeds from that point to the circumference. But when the matter has been infiltrated, as it more commonly is, this softening appears to commence at some internal but undefined portion of the diseased part, which proceeds till at length an abscess forms, which, for the most part, ruptures into one or more bronchi, and the pus is now thrown up by coughing.

In whatever stage the patient may fall, the deposition of tubercular matter does not take place with equal frequency in all parts of the lungs, but is principally limited to the anterior and superior lobes, only rarely affecting the inferior or posterior lobes.

In general both the superior lobes are affected, since Louis, out of 100 cases, only met with five instances in which it was limited to the left lung, and only two in which it was limited to the right lung. Posthumous examination also seems to show that the tubercular matter is deposited in crops in the superior lobes, and generally in three crops; that at the root of the lung, and immediately under the clavicle, being riper and more advanced; that in the middle portion in the crude state; and that towards its summit in the grey or granular state; showing, if the tubercular matter follows a similar course in different parts of the lung, that it must have been deposited at different times. Louis found only two exceptions to the law of the greater tendency to ripen under the clavicle.

When the tubercular mass is completely softened and converted into pus, the abscess formed is termed by the old masters, vomica; and by Laënnec, "*caverne*." The dimensions of the vomica are very various, sometimes not so large as a pea, while others occupy nearly the whole lobe. There may be only one vomica, but more commonly there are two or more; and, when multiplex, they may be isolated, or else communicate by fistulous openings. Sometimes they are deeply seated in the centre of the greatest thickness of the lung, while in other instances they are so superficial that the only remaining wall is the pleura, and this occasionally ruptures, causing pneumo-thorax, followed by pleurisy. In most cases, however, the abscess ruptures into one or more bronchial tubes.

The interior of the vomica is occasionally uniform and circular, but more commonly it is irregular and broken, and coated by a thin muciform matter rarely susceptible of organization. Besides being irregular, the cavity of the vomica is often traversed by portions of condensed pulmonary tissue infiltrated with tubercular matter. In very rare instances, says Laënnec, I have found *blood-vessels* in these "*brides*," or columns, but more commonly, if not constantly, they are *obliterated*. Indeed, it appears to be a law to which there are few exceptions, that the deposition of tubercular matter is so effected as to turn aside the blood-vessels without the walls of the vomica, and, by pressure, to flatten and obliterate them. It is extremely rare, consequently, for a vessel to be met with either in the abscess or in the tubercular mass; so that, if the lung be injected, the colouring matter seldom reaches the cavity. M. Guillot, however, by a series of minute injections, dissections, and microscopic observations, has further investigated the condition of the immediate walls of the abscess, and asserts that although no large blood-vessel is to be found within a considerable distance of the vomica, yet, after a time, a series of most minute vessels hardly a millimetre in diameter creep over the interspace between the periphery of the tubercle and the pulmonary artery, and communicate either with the bronchial arteries, or with the arteries of the thoracic walls, by many of the adhesions or false membranes. The congeries of these vessels under the microscope present an appearance of velvet; and in this manner, says M. Guillot, the blood is once more brought in contact with the atmospheric air, and returned to the heart by the pulmonary and bronchial veins, and by the vena azygos. If this statement be confirmed, it results, that the greater the extent of tuberculoma of the lungs the greater is the capacity of the capillary vessels for arterial blood, and may account in some measure for the florid appearance so often met with in the phthisical patient.

On the contrary, the tubercular matter is generally deposited *around* and in the bronchial tubes, and by its pressure quickly obliterates them; so that we never find bronchial tubes passing through a cavity, but always find them, as it were, closely cut off at its walls. This obliteration may constantly be shown, as it is rare to find a cavity, however small, into which one or more of the bronchial tubes do not open.

The walls of the vomica are formed sometimes by healthy condensed pulmonary tissue; at others by pulmonary tissue infiltrated with tubercular matter in some or all of its different stages; and occasionally by pulmonary tissue in a state of inflammation, or, according to Louis, in one case in 18. The matter contained in the vomica is often a white or yellowish pus, intermixed with portions of broken-down tubercular matter; but, in general, it may be said to vary from a bloody sanies to a laudable pus.

The ancients thought that vomicæ were capable of healing, if not of cicatrizing, and Laënnec conceives that his researches have proved this to be the fact. The process nature adopts to attain this end he conceives to be as follows: instead of the muciform matters which usually line the vomicæ, a distinct membrane is formed and organized, and which, instead of secreting pus, secretes a serous fluid. This membrane gradually becomes cartilaginous, and forms a cyst lined with a mucous membrane. The cyst thus formed may either communicate with the bronchi, or it may be closed and filled with a cretaceous or other matter. The objection to phthisis being cured in this manner, is, that many pathologists with extensive opportunities have never seen such a cyst. Another mode in which the abscess is supposed to heal, is by granulations after the manner of ordinary abscesses, and that its site is marked by a linear cicatrix of condensed cellular tissue. It is certain that these cicatrices are often met with when the lung is otherwise healthy; and one or more bronchi may sometimes be found terminating in them as in a cul-de-sac; but that they denote the healing of a vomica and not the healing of an ordinary abscess, or a ruptured air-cell, is by no means established. The possibility of a tubercular abscess healing and cicatrising may per-

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Elementary Principles of Medicine.

haps be established; but it must be admitted to be n circumstance of most rare occurence, and a singular exception to the general law of phthisis, being almost invariably fatal.

In examining the bodies of those that have died of phthisis, we find the lungs are not the only organs that have suffered in the general destruction that disease has inflicted on the human frame; for we discover a vast extent of disease either directly or indirectly set up in other organs of the body. Louis has, with great labour, noted the different concomitant affections which he observed in 102 persons dead of phthisis; and though they differ in some of the numerical statements from what has been observed in this country, they are perhaps the nearest approximation to the truth we possess.

Out of 102 phthisical patients, Louis found—

| | |
|---|---|
| The epiglottis ulcerated mostly posteriorly in | 18 |
| Larynx ulcerated . . . . . . . | 23 |
| Trachea ulcerated mostly posteriorly. | 31 |
| Acute final pneumonia . . . . | $\frac{1}{16}$ |

The bronchi were widened, thickened, or reddened, or presented small ulcers very frequently when leading from excavations. Louis also conceives bronchitis to be always produced when pulmonary tubercles soften. Pleuritic affections were nearly as constant as the bronchial affection, and he finds an uniform proportion between these two affections and tubercular disease.

*Complications affecting the Alimentary Canal.*

Of 96 phthisical stomachs $\frac{1}{5}$th only were healthy.

They were softened, thinned, reddened, thickened, or contracted in $\frac{4}{5}$ths of the cases; ulcerated in 2 cases.

The duodenum was ulcerated in 3 cases; follicles enlarged in some instances.

In the small intestines the patches of aggregate glands were ulcerated in $\frac{4}{5}$ths; while the mucous membrane was sometimes reddened, and but rarely softened and thickened.

In the large intestines ulceration a little less frequent, but more extensive than in the small.

Softening of mucous membrane in $\frac{3}{4}$ths of the cases of large intestines.

The mesenteric glands tuberculous in $\frac{1}{4}$th, mostly toward the cœcum.

The peritoneum in 4 cases recently inflamed.

1 case semi-transparent miliary tubercles.

The peritoneum, the mesentery, and omentum were thickened and tuberculous, and the seat of effusion in $\frac{1}{8}$th of the cases.

*Of the Accessary Organs.*

The liver was fatty in $\frac{1}{3}$rd of the cases.

The heart was generally reduced in size.

Pia mater infiltrated with serum in $\frac{2}{3}$ths.

Brain universally or partially softened in $\frac{1}{10}$th.

Of the preceding complications Louis considers all tuberculous deposits, ulcerated air-tubes and bowels, and fatty liver as proper to phthisis.

Such are the principal lesions found in phthisis.

Besides tuberculoma occurring in the substance of the lungs, the *pleura pulmonalis* and *costalis* may also be the seat of tubercular deposit. In the museum of St. Thomas's Hospital is a specimen in which a considerable number of tubercles, about the size of a bean, are situated immediately under the *pleura pulmonalis*, and having scarcely any connexion with the lung. When deposited in the sub-costal pleural tissue in the form of tumors, they vary in size from a millet-seed to a large pea. When miliary, these tubercles are often exceedingly numerous, amounting to many hundreds, and are generally found in a crude state; but instances have been met with of both the other stages. In other instances the tubercular matter is infiltrated into the substance of the pleura, and sometimes exuded at its free surface.

Laënnec has only met with three or four instances of tubercles deposited in the walls of the *heart*; and Dr. Baillie mentions only three cases in which there were tumors of this kind, each about the size of a walnut. Tubercle in the walls of the left ventricle occurred some years ago in St. Thomas's Hospital, in a man whose heart was greatly enlarged; it was about the size of a large bean, and softened. Tubercle of the heart is unquestionably a rare form of this disease.

### Of Tuberculoma of the Alimentary Canal and of its Auxiliary Viscera.

Tubercles have been met with in the tonsils; and Dr. Baillie states that he once met with a scrofulous swelling at the lower end of the *pharynx* and beginning of the œsophagus. It formed on that side of the pharynx which is next the larynx; and from this circumstance the patient had not only lost the power of swallowing, but was unable to speak except in the lowest whisper.

Tubercles are so rare in the stomach that Andral, notwithstanding his extensive pathological researches, only met with them twice or thrice. They are more common in the small intestines, especially towards its lower portion, and are again rare in the large intestines. They have three seats, or the sub-mucous cellular tissue, the interstices of the muscular fibres, and the sub-peritoneal tissue. In size they vary from a millet-seed to a pea, while, as to numbers, sometimes there is only one or two found throughout the whole intestine; but in other instances they are numerous. The mucous membrane around them may be healthy, simply injected, or ulcerated.

The *Spleen* is rarely seen affected with tubercles in the adult, and not commonly so in children. But in either case it is rare to meet with them in the spleen unless tubercles exist also at the same time in the lungs.

The *Liver* is more commonly the seat of tubercles than the spleen. They are sometimes extremely superficial, being seated immediately under the peritoneal covering, and in this case they are generally extremely numerous and small. In other instances they are deep-seated and large, varying from the size of a nut to an egg. There may be several, but their number is in general in the inverse ratio of their size, so that when large there is only one. They are commonly found in the crude state, and only rarely softened at their centre. Many pathologists have affirmed that they are never found in the grey semi-transparent or first stage in the liver, and the fact is certainly extremely doubtful; but in a case that died some years ago at St. Thomas's, a cyst was found containing a fluid which, from its grey gelatiniform character, appeared to be tubercular matter in its earliest state, and a similar instance or two may be found in other writers. The substance of the liver



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around these tumors is often healthy. Tubercles have also occasionally been found in the walls of the gall-bladder, and M. Lugol once found one as large as a walnut in the cystic duct.

Tubercles have occasionally been found in the *pancreas*, and Lobstein speaks of having met with five instances of them in this viscus in children. But still they are rare, for Lugol never met with an instance, and few authors have made any mention of them as incident to this organ.

In the *Kidneys* tubercles are common, and they may invade either the cortical, medullary, or the tubular structure. There are seldom more than five or six, and these vary in size from a pea to a nut, but they have been seen as large as a walnut. They have hitherto been found only in the crude or else in the softened state; when softened they often cause large and destructive abscesses of the kidney, with great thickening and enlargement of the ureters. Tubercular matter has also been found between the coats of the ureter, or secreted at its surface.

The *peritoneum* is also frequently the seat of tubercular deposit, both in the child and in the adult, and is one of the *tabes mesenterica* of pathologists. Its seat is the sub-cellular tissue, not only of the portion covering the walls of the abdomen, but also of that covering the intestines. In size the tubercle is not bigger than a millet-seed, but they are numberless; in general some slight inflammation of the peritoneum, attended with effusion of serum, usually accompanies it. When the peritoneum likewise is the seat of adhesion, or is covered by a false membrane, tubercular matter is very constantly deposited in the connecting cellular tissue in the substance and at the surface of the false membrane.

### Of Tuberculoma of the Glands.

In the *cervical* glands tubercles have long been designated by the name of Scrofula or *King's evil*. Indeed, the scrofula of the older pathologists for the most part was limited to tubercular affections of the glands. This disease may take place in infancy and in very early life, but it is much more common towards the end of the first or of the second septenary period, and indeed is met with at every period before 30. The tumors they form may exist on one or both sides of the neck; but, when double, they seldom attain the same excessive magnitude on both sides. Their volume is very various, sometimes hardly exceeding a plover's or a pullet's egg; but in other instances they acquire a size which may be termed monstrous, extending in bunches from the mastoid process to the middle of the lower jaw, to the clavicle, and even below it; and this formidable mass is sometimes increased by meeting with a continuous chain of enlarged axillary glands, and even with tubercles lodged in the mediastinum. When the disease is thus extensive the patient often dies from pressure on the larynx and trachea. On examining these vast tumors we generally find them to consist of a number of enlarged glands loaded with, or entirely converted into, tubercular matter, a few of them being softened in the centre. This mass of disease is usually surrounded by cellular tissue, more or less in a state of suppuration. The axillary glands are subject to a similar enlargement of firm tubercular deposits.

The *mesenteric glands* are often the seat of tubercles; and this is another of the forms of "tabes mesenterica." Many pathologists, however, and among them Lugol, consider the loose cellular tissue of the mesentery, and not the mesenteric glands, to be the seat of the tubercular deposit. Bœker has often injected, he says, the lymphatics with mercury in this disease, and has always found the injections pass freely through the glands; whence he concludes its seat to be the cellular tissue, and more especially that immediately surrounding the gland. It is probable, however, that both views are correct; and the latter accounts for the very considerable *embonpoint* which is sometimes seen in these cases. Still, in whatever tissue developed, the tubercular masses are often numerous and generally large, varying from a nut to an orange. Indeed, in no other region, says Lugol, do we find the masses of such a magnitude. These tubercles are often seen softened in the centre and very constantly contain calcareous matters, and are moreover often partially converted into bone. They seldom cause ulceration of any part of the intestine except the cæcum, with which, from its being bound down, they occasionally contract adhesion, and thus it becomes involved in the disease. In the great majority of these cases the body is singularly emaciated.

The *inguinal* glands are also in a few instances the seat of tubercles, and by their enlargement often make pressure on the nerves and blood-vessels about the abdominal ring, rendering this disease, generally void of pain in other parts, one of great suffering. The disease at length spreads to the deeper-seated glands, and the patient dies exhausted either by long-continued suppuration, or else from inflammation excited in the peritoneum.

The *bronchial* glands are perhaps in children as frequently the seat of tubercle as the cervical or the mesenteric. Those situated at the lower extremity of the trachea are most frequently affected, and sometimes they attain a large size and contract adhesion to the lungs. Under these circumstances they occasionally soften, suppurate, and ulcerate into the bronchi or pulmonary tissue, and the patient throws up pus as from a vomica or pulmonary abscess.

Tubercular tumors are also found in the *ovaries*; and Lugol mentions a case in which this took place in a young girl in whom these morbid productions likewise existed in the folds of the mesentery, in the cerebellum, and in the lungs. Tubercle has also been occasionally seen in the *uterus*, in the *testicles*, in the *vesiculæ seminales*, and in the *prostate*, and also in the coats of the *bladder*.

### Of Tuberculoma of the subcutaneous Cellular Tissue.

M. Lugol has seen two cases of tuberculoma in the cellular tissue immediately exterior to the bone. In one a tuberculous tumor successively destroyed the zygomatic process, a portion of the sphenoid, and also of the petrous portion of the temporal bone, so that it lay in contact with the dura mater. In the other case, a subcutaneous tubercular tumor gradually perforated the sternum, and thus arrived at the anterior mediastinum. Tubercles are also formed in the subcutaneous tissues of the face, forming "*acné*." They also sometimes form underneath the skin of the arms or thighs, or in the posterior region of the neck. The most general instance, however, of subcutaneous tubercle is in *Elephantiasis*, when the face, arms, hands, legs, and indeed almost every part of the superficies of the body is the seat of an endless succession of tubercles, forming, ripening, suppurat-

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ing, ulcerating, and healing; thus keeping up a ceaseless irritation, destroying the health of the patient, and producing a singular, thickened state of cutis and cellular tissue, the former becoming a dark brown *intermingled* with numberless white cicatrices.

### Of Tuberculoma of the Bones, Muscles, and Blood-Vessels.

Tubercles are occasionally formed in the very centre of the long bones, as the tibia, humerus, or femur, and the tumor is frequently surrounded on every side with healthy osseous tissue. More commonly, however, the tubercular matter is infiltrated generally into the cancellous structure of the small bones, as into the tarsal and metatarsal bones, the carpal and metacarpal bones into the heads of the long bones, the petrous portion of the temporal bone, and into the cancellous structure of the vertebræ. In these cases the osseous substance becomes so softened, so entirely deprived of osseous matter, as to be readily cut with a knife; or else so broken down by the superincumbent weight of the body, that the limb becomes shortened, as in hip disease; or else the person becomes permanently deformed, as in the hunch-backed.

Tubercles may be generated in the muscular tissue, and Lugol has met with them embedded in the psoas muscles, and entirely isolated from every other structure.

*Symptoms.*—As a general principle it may be affirmed that tubercular matter, being first deposited in a soft if not fluid state, and by an action either entirely void of all inflammation, or else of an achromatous character, is unattended with pain, and therefore gives little note of its early existence, except by some slightly impaired function of the organ or part diseased. Again, when the tubercle undergoes its transformation into the hard yellow opaque substance or crude tubercle, this change is often so gradual that the parts accustomed to its presence may even now be only slighty irritated. It seems an established law, however, that when the tubercle is about to soften, that the constitution not only takes the alarm, but great local and general irritation is now set up, and the patient's life, if the part be vital, rapidly verges towards a close. As the course of the disease is extremely short in some cases and extremely long in others, it may be *acute* or *chronic*.

*Symptoms of Tuberculoma of the Brain and Spinal Cord.*—Dr. Hennis Green has given an analysis of the symptoms observed in 30 children that died in the hospitals of Paris of tuberculoma of the brain. Thus in four cases no cerebral symptoms existed; in two it was only marked by periodic headache; and in two by deafness and purulent discharge from the ears. In nine cases the symptoms were those of acute hydrocephalus,—as headache, vomiting, amaurosis and convulsions; a few with symptoms of softening; while the rest died of consumption and of small-pox. The duration of these symptoms was very various, or from one month to three years. Other observers have mentioned great fretfulness of temper, contraction of the limbs, with a frightful degree of emaciation.

In the adult the formation of tubercle of the brain is often equally latent. In other cases, however, intense and continued frontal headache, tearing from the patient the frightful hydrocephalic cry, vomiting, impaired intellect and impaired motion, with perhaps occasional attacks of epilepsy, are its effects. Still these symptoms only denote an injured state of the brain, without indicating the particular cause, the same symptoms accompanying many other tumors and diseases of this organ. It seems, however, to be a received opinion that tuberculoma of the brain is seldom or never met with after the age of 45. The duration of this affection is often long, but the acute symptoms rarely last more than a week to a fortnight.

Tubercles of the cerebellum are still more rare than of the brain, and Andral has deduced from 20 recorded cases the following as their symptoms,—headache in 17; continued fainting and vertigo in 1; the sight weakened or lost in 7; the intellect impaired in 5; convulsions in 7; palsy in 8; vomiting in 10, while the genital organs were only abnormally excited in one.

The following case, given by Bayle, of tubercle in the medulla oblongata, shows the latency of the disease as well as also the occasional symptoms to which it gives rise. A man, aged 24, had laboured for some time under the ordinary symptoms of phthisis. Three days, however, before his death, he was seized with incessant twitchings of the tendons of his right hand, while his urine and fæces were passed involuntarily. Twelve hours before his death his fingers were bent on the palm, the hand on the fore arm, and the fore arm on the upper arm, and this affection was more marked on the right than on the left side; his face was also convulsively twitched. A tubercle about the size of a nut was found a little above the corpora pyramidalia and olivaria.

The symptoms of formation of tubercle of the cord are equally uncertain. In some cases the patient suffers atrocious pains in the back, while in others little or no pain is felt, but all below is benumbed or palsied. The following sketch of this disease in a man aged 54, and given by Gendrin, is perhaps a fair generalization of the symptoms. The first symptom was numbness of the lower extremities, followed by a total loss of sensation, with twitchings of the limbs, but the patient was still able to walk with a stick. This power quickly ceased, and he was confined to his bed, and ultimately died from obstinate constipation, retention of urine, and gangrene of the back. In another case, in which an encysted tubercle was found softened at its centre between the fifth and seventh cervical vertebræ, the symptom was epilepsy.

*Symptoms of Tuberculoma of the Lungs, or of Phthisis.*—As a general law, it may be stated that the presence of tubercular matter in the substance of the lungs, whether in its semi-transparent, crude, or softened state, does not cause the slightest pain to the patient; and when pain does exist in the chest or between the shoulders, it proceeds entirely from the effects of violent coughing, or else from inflammation, of no very acute character, of the pleura.

The greater number of cases of phthisis commence, then, with some slight cough, the sputa being hardly discoloured, or only slightly stained by a trace of pus or blood. The patient also is feeble, easily fatigued, has burning heat of the soles of the feet at night, and some perspiration in the morning; he is also irritable, his appetite capricious, and he is convinced of a sensible loss of flesh. At this period the sounds of the chest on percussion are healthy and perfectly sonorous under both clavicles, but the respiration is affected, being louder or more puerile in both lungs; or else it is feeble in one lung, and louder in the other, while the times of expiration are prolonged. These symptoms are accompanied by a

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permanently accelerated pulse, from 80 to 90, while a more fatal sign is present, or that of the heart being heard beating all over the chest, showing that the lungs are condensed, and thus rendered a better conductor of sound. This stage or state of things may last a few weeks or a few months; and even the patient often revives, and seems to an unpractised eye, for a short time, to have recovered his good general health.

The disease, however, silently proceeds, and all the preceding symptoms are gradually but sensibly aggravated. The hectic becomes permanently established, and the sweat from the head and chest towards morning is often so profuse that the patient lies deluged, and is obliged to change his linen; the cough is more distressing, the sputa purulent, the hæmorrhage more constant, and the pulse more frequent, or from 90 to 110. He now often vomits after each meal, and the emaciation consequently is well marked and decided. On percussion, also, a dull sound is now returned from under the clavicles; on auscultation we hear bronchophony: the heart's action is still more palpable over the chest; the respiration is accompanied by some mucous râle; while the times of expiration are still further prolonged. The duration of this stage is very indefinite, or a few weeks to many months, and during its progress the disease occasionally intermits and becomes latent, so that there is for a time often a marked amendment, and the patient regains some strength.

The third and last stage of this eventful disorder is that in which the tubercle softens and an abscess forms. In this stage all the preceding symptoms attain their highest degree of intensity; the hectic is now often followed by a cold clammy sweat; the appetite is lost; a colliquative diarrhœa often supervenes; the sputa are often pure, as from an abscess, but at length become æruginous, or little more than a rusty sanguineous mucus; the pulse rapidly increases to 110 or 150; the emaciation is frightful; and nothing, indeed, appears to survive this general wreck but the mind, which is often firm, collected, and even hopeful to the last. In this stage the phenomenon on percussion has undergone another alteration; the dull sound returned in the second stage now giving place to an unnaturally clear sound, in consequence of the introduction of air into the cavity of the lung; and, according to the condition of the abscess, we have now the râle amphorique, or the tintement metallique; while the mucous râle is for the most part tracheal. It is remarkable, however, that as soon as the abscess bursts the cough is often greatly relieved. The duration of this stage is generally shorter than the former, but still, notwithstanding the existence of one or more abscesses, it often lasts many months. Such is a short outline of the course and phenomena of this destructive disease, which sometimes terminates life within a month, a few weeks, often in a few months, while it occasionally lasts many years. The following is a short analysis of the principal, local, constitutional, and stethescopic symptoms of this remarkable affection.

*Affection* of the *Bronchial Membrane* is certainly the most frequent concomitant symptom of phthisis, but the part of the bronchial membrane affected is not always the same; most commonly the mucous membrane of the smaller bronchial tubes is first affected; then that of the larger ones, the disease gradually ascending till it often ends in a chronic laryngitis, with a partial or total loss of voice. In a few cases, however, this order is inverted, and almost the first symptom is a laryngitis, with hoarseness and constriction of the throat; after which the disease descends to the larger and then to the smaller bronchi, when the patient begins to expectorate; his pulse becomes hurried; he loses flesh; and all the unerring symptoms of phthisis are established.

The *expectoration* which takes place in phthisis from the bronchial membrane is usually purulent, the pus thrown up in the early stages being for the most part of good quality, and formed into "sputa," sometimes sinking and sometimes swimming in water; and may be either of a sweet, insipid, or saltish taste. As the disease advances, it is often thrown up pure, as from an abscess, and without any separation into sputa, and is sometimes mixed with particles of a curdy substance.

In the last stages it is often of an æruginous green, a dirty sanies, or a rusty muciform serosity. The quantity expectorated varies greatly; sometimes only a few sputa, or not more than half an ounce in the 24 hours, and then perhaps more than a pint in the same period, so that in a few weeks the patient has often expectorated more than his own weight of pus. If a small abscess has burst into the bronchi, the sputa, though something increased in quantity, are hardly changed in character; but if the abscess be large, the quantity thrown up is proportionally great, and *en masse*.

In a very few instances the commencement of phthisis is marked by the expectoration of a cretaceous matter, or of small calculi, or of small portions of ossified cellular tissue. In some rare instances, also, the patient dies of *Phthisis sicca*, and without suffering from any expectoration whatever. If the bronchial membrane be examined after death it rarely presents any definite trace of inflammation; and Louis considers it to be in general healthy, except in those tubes which lead to the vomica or abscess. It appears, therefore, to be a strictly achromatous inflammation

*Hæmorrhage* may precede, or be contemporaneous with, or succeed to, the bronchial affection. If it precedes, the patient being, as he imagines, in excellent health, is suddenly seized with hæmoptysis, followed perhaps by cough. This attack subsides, but a second and a third follow, till phthisis is established. Hæmoptysis more commonly, however, occurs later in the disease, increasing the debility, aggravating the symptoms, and hastening the fatal catastrophe. The quantity of blood lost is very various; sometimes only enough to streak the sputa, at others a few tea-spoonfuls, but in some instances is so profuse as to amount to one, two, or more pints. In the still more advanced stages, though cases occur in which the quantity of blood thrown up is very great, yet more usually it is trifling, and more resembles a bloody sanies than pure blood; indeed, from the generally small quantities of blood thrown up in phthisis, it is almost an axiom in medicine that trifling hæmorrhages are more dangerous than large ones. The blood thrown up may be florid or dark coloured; in either case it probably escapes from the same vessels, the colour varying according to laws not yet determined.

The *cough* is as variable as the other symptoms. In some few cases the patient dies from tubercles in the lungs, and yet no cough is present. More commonly, however, the cough is troublesome, and often intense, so that every change of position, even turning in bed, the act of speaking, of eating, or of drinking, gives rise to it. Often it returns in fits or paroxysms, occurring at

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uncertain periods. It is singular that, as the disease advances and large abscesses open, that the cough, which was at first frequent and troublesome, often becomes comparatively tranquil, or is only excited to expel the purulent matter collected in the bronchi. A tickling cough usually denotes some affection of the glottis and larynx, parts which are more irritable and more abundantly supplied with nerves than the trachea or bronchi.

The *dyspnœa* is generally great in phthisis, the patient being unable to make any active exertion, or even to read a few lines without pausing. The dyspnœa, however, is not always proportioned to the amount of mischief; for there are instances in which the respiration has been performed with facility, even when two-thirds of the lungs have been in a state of tuberculoma. It is doubtful whether adhesions, unless very extensive, greatly affect the respiration. Should effusion of serum, however, or of pus from the bursting of an abscess, have taken place into the cavity of the chest, then the respiration is greatly impaired. The most common situation of the fistulous opening, caused by the bursting of an abscess into the chest, is the summit of the lung, or a little below the clavicle. It is usually very small, hidden by the lung, or so surrounded by adhesions that it is difficult to discover it. Again, when the abscess bursts not only into the chest but also into the bronchi, a "*triple opening*" is said to be established, and the disease is termed *pneumo-thorax*. When this latter event occurs, the life of the patient might be supposed to rapidly terminate, either by pleurisy or an entire exhaustion; but it is singular the patient often survives this state many days, sometimes a few weeks, and Louis has given instances in which two or three months elapsed before the death of the patient.

*The Stomach* is supposed to be more or less diseased in three-fifths of the cases of phthisis; yet it so seldom gives rise to any well-marked symptom that for the most part the affection may be said to be latent. In the worst cases the symptoms are only a capricious appetite, indigestion, some pain in the epigastrium, and vomiting after coughing.

*The intestinal canal* is at least as frequently affected as the stomach in phthisis; but in general the abdomen is without pain, and, in the early stages of the disease, supple. The only marked circumstance connected with this viscus in this stage is, that the stools are more copious than in health, the body being unable to appropriate the accustomed quantity of nutriment prepared by the stomach. As the disease advances the patient often suffers from irritable bowels, or from diarrhœa alternating with constipation; while, towards the close of the disease, the diarrhœa often becomes colliquative, hastening the fatal result. In some very few instances the peritoneum ruptures, and the patient dies of *peritonitis*, while in a somewhat larger number *Dropsy* takes place—Louis says in one case in four.

*The Liver* undergoes a fatty degeneration in about one-third of the cases, and so remarkable a lesion might be expected to give rise to some particular symptoms; but this is not the case; it may occasionally be felt somewhat enlarged, but neither pain, nor altered state of the secretions, or other circumstance, denote its diseased condition.

*Of Hectic.*—In some very few cases the patient passes through this disease without any attack of fever; but in the large majority of persons no sooner is the "crude tubercle" established than the constitution suffers, and hectic of a marked character appears. The simplest form of this fever is a periodical return of a burning heat in the palms of the hands and soles of the feet. More commonly, however, the hectic fever is more complex, and the patient is seized with quotidian paroxysms of intermitting fever, so that many patients consider themselves to be labouring under that disease, the paroxysm consisting of shivering, fever, and profuse sweats. The time of the recurrence of the paroxysm varies, for it may come on in the morning or in the middle of the day, but is most common perhaps in the evening.

In many instances one or more of the stages of the paroxysm is wanting. Thus many patients suffer once in the twenty-four hours from coldness and shivering, without these being followed either by fever or sweating, and in like manner the paroxysm may consist solely of the hot or of the sweating stage. More commonly, perhaps, the paroxysm consists of two stages, as the cold stage and the sweating stage, or of the hot stage and of the sweating stage. The cold clammy perspirations which mark the former are the horror of every person labouring under this complaint. In the latter the attack generally takes place about five o'clock in the morning, when the patient awakes drenched in a perspiration so profuse that his body and bed-linen may be wrung. His head and chest are the parts from which it principally flows, and as the paroxysm subsides the urine often deposits a pink sediment. Louis found that in about one-fifth of his cases the attack of hectic was established before any abscess or cavity was formed in the lung, while in three-fifths it was deferred till after a cavity or vomica had formed, whence he concludes that the constitutional affection is not the result of the formation of pus, but is a law incident to tuberculoma generally.

*The pulse* is, in a very few instances, of its normal frequency throughout, or nearly so, the whole of the disease, but in 99 cases out of 100 it is small and accelerated in every stage; or, while the disease is yet incipient, it ranges from 84 to 96; in a more advanced stage it varies from 110 to 120, and towards the close of the case it often exceeds 130, 140, or 150, so as hardly to be counted. In many instances the pulse continues stationary at about 96, till the hectic comes on, when it becomes rapid, but as the fever subsides it again returns to its usual beat.

*The emaciation* so remarkable in this disease is common to nearly all the tissues of the body, as the adipose tissue, the muscles, the bones, and even the intestines and skin are thinned. This emaciation often commences even before the disease can be said to be well established, so that the patient has often lost one or two stone before he applies for medical advice. In the more advanced stages the rate of emaciation is singular, the party losing perhaps three pounds in one week, and gaining two pounds and a half in the next, and this alternation of gain and loss goes on for many weeks, or months, always leaving a balance against the patient. Towards the close of life the loss greatly surpasses the gain, and occasionally amounts to four, five, six, and seven pounds in a week. The total loss the patient sustains is perhaps from one-third to half his whole weight.

The *mind*, though not capable of exertion, is perfect throughout the disease, or only wanders during the few

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last days of existence. It is seldom the patient dreads the future or despairs of the present, for nature, however threatening his symptoms, has imparted a singular buoyancy to his hopes, and he is always better; would be quite well but for his cough; feels able to take a long walk, and enjoys in expectation his meals; yet, with all this, he faints if he attempts to cross the room, and nauseates his food when brought to him.

Such are the general and local symptoms of phthisis, and which are sufficient indications that the lungs are diseased. The stethescope, however, adds many interesting additions, and enables us to determine not only that the lung is diseased, but the particular part of the lung which is diseased, and likewise the present state of the diseased part; and thus the discoveries of Laënnec and of Avenbrugger have rendered the diagnosis of Tuberculoma of these organs almost as perfect as though the disease was exposed to sight.

*Physical Symptoms.*—If we uncover the chest of a patient labouring under cough and other symptoms of incipient phthisis, we observe nothing remarkable, except as a general rule that its transverse diameters are small. If the disease be further advanced, we find the patient emaciated, together with a singular immobility or incapacity of dilatation of the portion of the chest immediately below the clavicle, so that he breathes chiefly by his shoulders and diaphragm, and is unable to "fill his chest." In the latter stages of the disease, the whole of the affected side of the chest, viewed anteriorly, is perfectly motionless; at a still more advanced stage, if an abscess has burst into the cavity of the pleura, and caused *pneumo-thorax*, the affected side is not only motionless but distended, and as it were bulging out. The examination of the bared chest, therefore, often affords valuable data for forming a diagnosis in phthisis.

If we apply the stethescope to the chest in incipient phthisis, the action of the lungs is perhaps little impaired, but we hear the heart beating all over the chest, and at a rate which varies in different subjects from 90 to 100. This symptom, if heard repeatedly, is always of anxious portent, for it denotes the density of the lungs to be increased, and thus rendered a better conductor of sound, and no cause is so constant of this change of density as tubercular infiltration. At this period air permeates the pulmonary tissue generally, so that percussion is still followed by a clear sound.

In the second stage, or that of crude tubercle, the density of the lung is still further increased, and the heart is consequently heard still more distinctly beating all over the chest. We have also the phenomenon of bronchophony. We hear the louder pulmonary *bruit* in the healthier lung, and a more feeble one in the most diseased lung, accompanied for the most part with bronchial or tracheal mucous rhoncus. On percussion, also, under the clavicles, the sound now returned is dull.

When the tubercular matter is softened and forms an abscess or vomica, we have, when the conditions are favourable, pectoriloquy, but much more commonly only bronchophony. If the conditions also be favourable, we can determine by the absence or presence of the *souffle voilé* whether the abscess be superficial or deep seated; also whether it be large, for in this case we have the *râleamphorique*; or on the patient coughing, a gurgling or splashing sound, or else the *tintement metallique*. We can determine also whether it has burst into the cavity of the chest, causing pneumo-thorax; by the affected side of the chest becoming enlarged and motionless; and by the remarkable circumstance of the "*tintement metallique.*" On percussion, also, under the clavicle, every part of the chest, even that which so lately returned a dull sound, now returns an unnaturally clear sound.

In the first stage of phthisis, says Andral, the blood offers no peculiarity, except that the clot is generally small and dense, containing a smaller proportion of red globules than usual, while the quantity of fibrine is normal.

In proportion, however, as the disease advances, and that the tubercles soften and caverns form, the clot still further diminishes, but is covered with a buff, which is thicker and firmer in proportion as the disease is more advanced. Two circumstances contribute to the production of the buff, or the increase of fibrine, so common in the last stages of phthisis, and again the continued diminution of the red globules. The buff in the last stages of phthisis is as common as in pneumonia, or in acute rheumatism.

These are the general local and physical symptoms of phthisis, a disease which can only be confounded with chronic bronchitis. The diagnosis, however, between the two diseases, is often extremely difficult, sometimes impossible, the patients equally labouring under cough, expectoration, emaciation, and hectic fever. The absence, however, of the dull sound on percussion, as well as of pectoriloquy, give a reasonable ground for believing that the disease may still be classed as bronchitis, and that the patient is not labouring under phthisis.

The *Prognosis* is universally fatal.

### Of the Symptoms of Tuberculoma of the Alimentary Canal, and its accessory Organs.

No symptom is yet known by which tuberculoma of any portion of the alimentary canal can be determined during life; for the symptoms common to this disorder are common to many other alterations of structure, and even of function of these parts, and the only ground for inferring its existence is the fact of the patient labouring under phthisis. The leading symptoms are diarrhœa, and perhaps some slight peritoneal pain or irritation.

When tubercles form in the liver or spleen, those viscera are commonly greatly enlarged, but not the seat of pain or of much local inconvenience; the constitution, however, is at length affected, the peritoneum sympathizes, and dropsy follows. In the liver, when the tubercle is superficial and large, it may sometimes be felt through the abdominal walls during life. But the spleen being deeply seated, and the tubercle generally small, it may perhaps be inferred, but can seldom be discovered by the touch.

In the kidney, tubercles form in the same latent manner, and without pain. They also lead to dropsy; still the dropsy has no particular feature, so that until the kidney be examined after death, the real cause is seldom either inferred or discovered. In the event, however, of their determining an abscess of the kidney, the presence of pus in the urine, the lumbar pains, and the infrequency of abscess of that organ from any other cause, may lead us to infer the presence of a tubercle of the kidney.

The formation of tubercles of the peritoneum is perhaps equally latent, but from the irritable character of this tissue they shortly give rise both to local and constitutional symptoms. In general chronic peritonitis is set up, accompanied with much pain, increased on pres-

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sure, and by a small and extremely rapid pulse, and this is shortly followed by effusion into the cavity of the abdomen. Tuberculated peritoneum may be distinguished, however, from chronic peritonitis by the previous hectic state of the patient and his great emaciation, and by the existence generally of tubercles in some other organ or tissue of the body.

Tubercles of the *cervical glands* often acquire a great size without giving pain. At length, however, they become inconvenient from their great enlargement, so that sometimes the respiration is greatly impaired by their pressure on the trachea, and death has ensued, notwithstanding tracheotomy has been performed,—a result which, as the patient breathes freely, seems to demonstrate that the disease is not only local but constitutional. When the tubercular deposit is small, the glands and surrounding cellular tissue often suppurate, and a troublesome discharge ensues, but ultimately the patient recovers with his neck scarred. This is one of the few instances in which the patient survives this formidable disease.

When tubercules form in the *inguinal glands*, the disease is perhaps at first latent; but no sooner does it become active, and suppuration takes place, than the disease spreads inwards, the peritoneum becomes affected, and the patient, for the most part, ultimately falls from this formidable complaint.

The deposition of tubercular matter in the *mesenteric glands* is similarly latent; for whether the disease be acute or chronic, the patient suffers no pain. The chronic form is the most usual, and the early symptoms are—an inordinate appetite, with loss of flesh, while the stools are much more copious than in health. As the disease advances the pulse becomes rapid, the emaciation extreme, the appetite capricious, or altogether lost, and at last a colliquative diarrhœa closes the scene. In a few cases this form of tabes mesenterica is acute, and its course so rapid that the patient falls before emaciation can take place. A woman about thirty-five was admitted into St. Thomas's Hospital with diarrhœa, sickness, and a rapid pulse, but no pain was caused by pressure over the abdomen. She died within a week, when, on examining her, the mesentery was found to be the seat of many tubercles, as large as small walnuts, of which many were softened and purulent at their centres. She was a corpulent person, and had at least two inches of fat on the ribs. Lugol has seen many similar instances of embonpoint, and considers that the glandular structure is consequently not the seat of this affection.

When tubercle is deposited in the *bones* of the extremities the disease is at first equally latent, but as it advances the sufferings of the patient are great, the cartilages become affected, suppuration takes place, fistulous openings are formed, while from the softened state of the diseased bones the superincumbent weight of the body crushes them, and the limb is shortened. If the disease be situated in the vertebræ these bones are equally broken down, so that pressure is made on the spinal cord; the patient now suffers great pain down the back, and the power of locomotion is often greatly impaired. The displaced parts, however, at length become accustomed to their new condition, and the disease often terminates by anchylosis; and this having taken place, the patient, though deformed, recovers, and perhaps ultimately enjoys a considerable share of health. If the disease should take place in the long bones, as the head of the femur or its condyles, there is the same latency, followed by great suffering, which often destroys the patient before the disease has run its course and the tendency to health restored.

The many tubercular affections to which the cutaneous tissue is subject, cause but little constitutional affection, neither is the local inconvenience great; the patient, indeed, is annoyed by the unsightliness they occasion, but even in elephantiasis he often survives many years.

*Treatment*.—It appears, from the preceding statement, that tubercle has a natural tendency in some tissues, as the bones, the cervical glands, and the cutis, after destroying or impairing the part, to terminate in the patient's recovery. When, however, the tubercular deposit takes place in the brain, the lungs, the liver, the spleen, or other important organ, the patient is uniformly destroyed. The treatment, then, of tuberculoma resolves itself into what can be done in those cases in which there is a natural tendency to a return to health; and, on the contrary, in those cases in which the termination is inevitable death.

When the tubercle, then, is deposited in the bones, in the cervical glands, or other parts in which there is a natural tendency in the disease to subside, it is important, whether suppuration has or has not taken place, to support the strength of the patient by quina, sarsaparilla, the iodide of potassium, or other tonic, as also by wine and a generous diet, and the disease thus treated sometimes subsides before the patient's health becomes irretrievably lost. It is remarkable that all local treatment in these cases, as by poultices, ointments, or washes, is in general injurious. In the event, however, of this treatment failing, it may be a question, supposing a joint to be affected, whether the patient should not be advised to submit to the amputation of the limb.

In the treatment of the far larger class of tuberculoma of those organs in which the natural and inevitable tendency is towards death, it is to be regretted that its fatal course is little if in any degree retarded by medicine. We possess no cure at present for tubercle of the brain; and it is admitted, with hardly an exception, by the whole medical profession, that we possess no remedy for phthisis; and the same admission must be made as to the impossibility of our at present curing or even influencing the course of tubercle of the liver, spleen, or kidney, or of the mesenteric or cervical glands, or of tubercle infesting serous or mucous tissues. The cure of all these forms of tuberculoma will probably ultimately be found to yield to some specific medicine hereafter to be discovered; but till that happy event shall take place, the resources of art are limited entirely to palliatives; we shall limit the few remarks we have yet to make on this distressing subject to the treatment in phthisis.

Phthisis has been often treated on every general principle that could affect the part through the medium of the constitution: thus the patient has been bled, both generally and locally, and the blood drawn has been in every quantity; but as a general rule it may be affirmed, that in proportion to the quantity of blood taken, so has been the rapidity and the fatality of the disease: counter irritations, also, of every kind have been employed; and yet, as far as we can judge, without any favourable results. The patient has likewise been treated with every known purgative, either to regulate the bowels, or else with a view to a more active operation, and also with every known emetic, either with the intention of easing the cough, or else of producing vomiting, and



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yet the party has in no instance been ultimately benefited. In like manner, every tonic remedy has been tried; but the constitution has in no instance been so influenced as to lead us to imagine that the disease has been cured. The failure of every mode of *general treatment*, therefore, necessarily shows that the remedy, when discovered, must be of a specific character.

The number of substances which have been exhibited in the hope of finding this specific is quite remarkable; yet none of them has in any sensible degree affected either the symptoms, or the course of the disease, or visibly accelerated or retarded its so constantly fatal termination. Every metal of which half an ounce could be procured has been tried in some form or other, even to osmium, so difficult to procure, on account of its volatility, and yet without any sensibly good effect. One of the most remarkable results of these various trials is, that it has been found that minute doses of arsenic, exhibited for a few days, have improved the sputa, and appeared to benefit the patient, but if continued longer, the effect has been injurious; mercury is in every case injurious, and its use even predisposes to the disease. Every mineral acid has been tried, even to the fluoric, so seldom obtained without impurity, but with the same negative result. Each known vegetable acid has been put in requisition—as the tartaric, citric, gallic, benzoic, oxalic, and hydrocyanic, &c., but without benefit. Neither have the many alkalies now discovered, whether exhibited simply or in combination, been productive of any more satisfactory result. Almost every wood, and also the bark of almost every wood, has been alike tried for this great end, as also a numberless amount of seeds, as well as almost every bulbous root. The only substance, however, out of these extensive classes of possible remedies that has produced any very sensible result, was the cevadillo, which is supposed to contain veratrine; and in the small number of cases in which this was tried it appeared rapidly to enfeeble the powers of the patient, and to hasten his death.

In conclusion, every oil, whether fixed or volatile—every opiate, and every æther has been given—every gas, also, that the ingenuity of modern chemistry has discovered, has been inhaled without producing any sensible benefit. The extent to which these attempts to cure phthisis has been carried, has shown how very few of the substances with which nature has surrounded us are actually injurious, and is consequently a strong argument for pursuing this interesting path of inquiry; for the powerful remedies we possess in controlling and curing many other diseases is a most convincing reason that an antidote or specific remedy for phthisis will ultimately be discovered.

As the cure of phthisis is still a problem, the only hope of a family predisposed to this disease escaping is by prevention. But as the remote cause is so obscure, so the avoidance of it is a matter of vast doubt and difficulty. Still, it being well known that the artificial habits of domestic town life are more favourable to its production than those of a country life, it may be determined as a general rule, that a predisposed person should, if possible, reside in the country, accustom himself to exercise, and expose himself, when properly clothed, to the weather. It may be questionable, also, whether the habits of drinking everything hot, and everything impregnated with some foreign substance, as tea, coffee, chocolate, or beer, does not impair the digestive organs, debilitate the system, and facilitate the production of this disease. The stalled ox, artificially fed on boiled food and hot mashes, falls an easy and ready victim to this disease; and horses, it is well known, that drink foul and dirty water, although they become so fond of it as to drink none other, usually become broken-winded, or otherwise affected in the lungs.

After phthisis has formed, no question is more distressing to answer, when it is evident all our remedies are failing, than "What is next to be done?" Should the patient try change of air? Change of place, however, appears to suggest itself in all countries, but perhaps rather as a relief to the physician, than as an efficient resource for the patient. If the disease, then, break out in the Mediterranean, it is the practice to send the patient to this country to prolong his existence. Again, if it break out on the continent of America, the patient is sent to the West India Islands; and if in the West India Islands, he is sent to the continent of America. In like manner, it is the practice in this country to send the patient to the south of France, to Madeira, to Malta, or to Naples; but alas! how few return to boast of the benefits they have received.

It may be stated that diet has little influence over the disease, when once formed; and it is of little moment as to the ultimate result, whether the food of the patient be strictly animal, strictly vegetable, or whether it be mixed. It is perhaps also of little moment what sort of wine the patient drinks, and some have even drank pure æther, without sensible injury; even a strictly water diet would perhaps be little serviceable in the cure of the disease. The only useful directions, therefore, that can be given for avoiding this disease, is to live as much as possible in the open air, to change place as often as the convenience of the party permits, and perhaps in most instances to seek a more southern climate, when this point can be easily attained. The party ought also to wear flannel.

The disease being once established, we have only palliatives to assuage in some degree the symptoms. Mild opiates, as the syrup of poppies, afford great relief to the cough, and are remedies for which the patient expresses himself most grateful; the heavier opiates, however, are in general less beneficial, and often produce headache. Against the night sweats the infus. rosæ c. sp. ætheris nitrici ʒ j. 6tis horis is our best palliative. When hæmorrhage comes on, it is best met by the bitartrate of potash; but as we are combating a symptom, rather than an original disease, this potent medicine is often inefficacious; and where diarrhœa threatens to accelerate the fatal catastrophe, a few doses of the mist. cretæ comp. c. opio, or else a drachm of syrup of poppies after each stool, often give a salutary check to this rapidly debilitating state. The frequency of the pulse is seldom controlled by digitalis; and even when most successful, the patient is more distressed by the medicine than benefited by the result. Whatever other symptoms may arise should be treated in the mildest manner, and with our simplest remedies, for even removing the accident, however distressing, is always followed by a declension of power, which is rarely recovered from.

Phthisis is in many parts of the continent supposed to be contagious, and the clothes and bedding of the deceased patient are immediately burnt. There is no sufficient reason, however, from any evidence afforded by the disease in this country, to suppose this disease

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can be communicated from one person to another. In some few instances a wife has appeared to have contracted it from her husband, or the husband from his wife; but in a disease of such common occurrence, such events must occasionally follow one another, and can hardly be considered as remarkable or as necessarily connected; and, taking them altogether, they are too few to warrant the adoption of the doctrine of phthisis being a contagious disorder.

### Order IV.—Of Carcinoma.—Cancer—a Crab.

Carcinoma is a peculiar morbid growth or substance, formed principally in the cellular tissue, but likewise in every other tissue and organ of the body. It was a disease well known to the ancients, and derives its name from the appearances it gives rise to in the female breast,—the superficial veins of that part, when affected with cancer, becoming enlarged, radiating, and having thus some resemblance to the claws of a crab. In modern times the development of its laws has employed the pens of Hey, Lobstein, Recamier, Andral, Carswell, Kiernan, and of many others. This formidable disease, according to the returns of the registrar-general, destroyed 2488 persons in England and Wales in 1839.

Carcinoma may be divided into carcinoma durum and into carcinoma molle, or into hard cancer and into soft cancer. This division is established on differences observed in their course, and in their phenomena, especially those of the second stage; also from their affecting, for the most part, different organs and tissues, as well as persons at opposite periods of life. It is probable, however, that in some instances, as in cancer of the breast, the two forms may co-exist. The cases of soft cancer are far more numerous than those of hard cancer, but the ratio is not determined.

### Of Carcinoma Durum.

*Remote Causes.*—The remote causes of Carcinoma Durum are extremely obscure. For it appears to be connected with a particular idiosyncrasy or constitution; but how that idiosyncrasy is formed has not as yet received any elucidation. There seems little doubt, however, of its being constitutional; for if the disease occurs in a part capable of being amputated, and it be amputated, nevertheless the disease returns for the most part either in that or in some other part of the body. The disposition once formed, all that depresses the vital powers appears to be productive of this disease: thus great mental depression appears to have been an exciting cause in Bonaparte, who, after his endless series of disasters, ultimately died from cancer of the stomach. In other cases it appears to be caused by mechanical injuries, and from accidental exposure to the weather.

*Predisposing Causes.*—Hard cancer seldom occurs till after 40, and from that period the liability increases with age. Its connexion with age may be best exemplified by stating, that its more usual seat are those organs whose vitality or functions are considerably impaired by time. Thus it seldom occurs in the mammæ, uterus, or in the ovaries till after the cessation of menstruation—nor in the organs of generation of the male till towards old age, nor in the different portions of the alimentary canal till after 40. Cancer is supposed likewise to be in many instances hereditary, and to run in families. It also very constantly occurs in persons of considerable physical power, and remarkable for their patient suffering, as well as for intellectual superiority.

*Pathology.*—Carcinoma durum has two stages,—or a hard or schirrous stage, and a stage of softening.

In carcinoma durum the cancerous matter is always deposited in a hard or schirrous state, and the duration of this state constitutes the first stage. It may be deposited in *masses*, or else be *infiltrated* into the cellular tissue of the organ or tissue affected; and the latter is by far the most common form. When formed into masses they are generally lobulated, dense, and often contained in a cyst; again, when these masses are cut into, we find them to consist of two substances,—the one is the cancerous deposit or growth, and the other is cellular tissue; so that the appearance of the divided surface in general is that of a hard, white, semi-cartilaginous substance, streaked by fibres radiating from the centre to the circumference. They are of considerable density and firmness, and in hardness of texture vary from hard boiled white of egg to cartilage—the knife crying as it cuts through them.

The cancerous deposit, however, is much more frequently infiltrated into the cellular tissue of the different organs or tissues it affects. In this case the affected tissue becomes gradually increased in thickness and in density by a slow deposition, or else growth of this matter, so that the part, if now divided, presents the same hard semi-transparent character as in the masses, but more interspersed with cellular tissue, the diseased portion being gradually shaded off into the healthy membrane or tissue. In the mucous tissues, as those of the stomach or uterus, the infiltrated matter has often a considerable thickness, measuring from a quarter of an inch to an inch, or perhaps even more. On the contrary, when infiltrated into the cutaneous tissue, the layer is often so attenuated as to be scarcely sensible, and the disease commences with little other appearance than a small hard pimple, or a small erysipelatous tumor, or even by a slight fissure or crack in the skin.

After a certain but indefinite period, which varies from a few months to a few years, the schirrous stage terminates, and the second stage, or that of *softening*, begins. In mucous membranes this softening usually takes place at their *surface*, or superficially,—as at the mucous surface of the neck of the uterus, or at the mucous surface of the stomach. An ulcer is the consequence of this softened state, and is at first superficial, and presents many remarkable varieties, as an inverted or everted edge—an irregular form, while its base may be granulating at one part and sloughing at another. Its course is burrowing, often penetrating between the cancerous lobules and perforating the peritoneum. The pus secreted by this sore is fœtid; often a mere ichor, or else pus mixed with blood, and so acrid as to inflame the parts over which it flows. In a few instances the large vessels participating in the disease ulcerate, and the patient dies of hæmorrhage.

The duration of the schirrous stage of a cancerous tumor, it has been stated, is very uncertain, and may terminate in a few months, or may last several years. A cancerous mammary gland, for instance, has been known to remain indolent for 14 years, and has at the end of that time been removed by an operation. This indolent character of carcinoma is limited, however, to the schirrous stage; for after it has softened, or its second stage commenced, its course is rapid, and a few weeks or a few months now generally terminate the patient's life,

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the part affected in no instance cicatrizing, or being again restored to a healthy condition.

Mr. Hecht, jun., has examined the chemical properties of a large schirrous mammary gland, and also of a schirrous uterus, and his analysis is as follows:—

Schirrous mammary gland.

| | Grains. |
|---|---|
| Albumen | 2 |
| Gelatine | 20 |
| Fibrine | 20 |
| Fluid fatty matter | 10 |
| Water and loss | 20 |
| | 72 |

Schirrous uterus.

| | Grains. |
|---|---|
| Fatty matter | 10 |
| Fibrine | 10 |
| Gelatine | 15 |
| Water | 35 |
| | 70 |

It is remarkable that neither of these analyses show the existence of any of the usual salts of the blood, while calcination gave for a residue only five grains of carbon. The truth of these analyses, however, is questioned by Müller; for he says he has boiled these tumors from 18 to 24 hours, and only obtained a very small quantity of gelatine; he considers them to be for the most part albuminous, and to contain some caseine and salivary matter.

Many different opinions have been entertained of the origin and intimate structure of cancer, and also of its essential character. Adams considers it to be caused by an animal of the hydatid species, which he calls hydatis carcinomatosa. While Broussais considers it to be a product of inflammation, although there is hardly a trace of a blood-vessel to be seen either in the tumor itself or in the surrounding parts. As to its peculiar nature, as developed by the microscope, Müller considers it to be characterized by a number of spindle-shaped or caudate bodies; while Mr Kiernan considers it to be composed of enlarged and varicose capillaries. With respect to its more essential character, some consider it to be a heterologue deposit, and devoid of organic life; while others view it as a substance or growth, enjoying an independent life, and attacking every organ or tissue that has a feeble vitality.

A more important question is, whether the secretions from a cancerous ulcer are contagious; and there is every reason to believe that this loathsome disease cannot be communicated. Alibert has made dogs swallow the ichorous serosity collected from a cancerous ulcer, but the health of those animals was not impaired. Dupuytren has likewise introduced portions of cancerous parts into the stomachs of many animals—has injected the pus into their veins, and into their different serous cavities, but without producing any other result than any other irritating matter would have caused. Women also having the neck of the uterus destroyed by carcinoma have conceived and borne children, and yet neither the husband nor child have appeared to suffer in consequence. Alibert and others have likewise inoculated themselves with cancerous matter, and yet no contagious effect followed. Neither has this disease at any time been known to result from accidents incident to the examination either of the living or dead person.

In the first stage, the blood in cancer, as in tubercle, is normal in the quantity of fibrine; but in the second stage that substance is, for the most part, increased.

Such are the general laws of *carcinoma durum*, a disease which attacks principally the skin, the mammary glands, the lymphatic glands, the uterus and ovary, the epididymis, and testicle; also the mouth, tongue, and the alimentary canal from the pharynx to the rectum. Indeed, it seems limited to these parts, probably never affecting the viscera, the bones, or the muscles. It is now, however, necessary to describe more minutely the disease as it affects particular parts.

The *tongue* is sometimes the seat of this afflicting disease, which begins by the formation of a tumor, generally small, but hard or schirrous. This tumor, though long indolent, is, at the end of a greater or less length of time, the seat of severe lancinating pains, which are the precursors of its softening. The softening of the cancerous tumor at length takes place at its superficies, and the surface of the tongue ulcerates, and the edge of the ulcer is thickened and contracted, so that it is partly inverted and partly everted, while its base is hard, livid, or bleeding, and its secretions fœtid. The progress of the disease is still slow but unerring, and towards its close a large portion of the tongue is seen eaten away; the sub-lingual and sub-maxillary glands enlarged and involved in the cancerous formation, and the mouth generally in such a state that the patient is reduced to a spoon diet, swallows the cancerous ichor with his food, becomes greatly emaciated, and at last dies, perhaps of hæmorrhage, an object of loathing to himself and of pity and commiseration to others.

Cancer of the *tonsils and pharynx* is rare, although the tonsils are greatly liable to be simply hypertrophied and indurated. The disease usually begins with some difficulty of swallowing, when, if the amygdalæ be the seat of the disease, we find them enlarged; or, if the pharynx, we perceive a hard circumscribed thickened mass occupying a greater or less extent of the pharyngeal membrane. After a considerable period of indolent inaction, lancinating pains shoot through the part, followed by the peculiar ulceration, which extends in spite of every treatment, till at last the amygdalæ, the pharyngeal membrane, the soft palate, the posterior palatine bones, the glottis, larynx, base of the tongue, and the base of the skull, are perhaps all destroyed, and the dura mater exposed, and in this dreadful state the patient sinks, grateful for the relief death affords.

The *œsophagus* is more frequently affected with hard cancer than any of the preceding parts. The first symptoms are a difficulty of swallowing; and, if the probang be passed, an obstacle is felt. The disease, at first indolent, at length becomes active, and the patient falls. The morbid appearances which present themselves after death are—a more or less irregularly contracted state of the œsophagus, often extending for several inches, and sometimes reducing the diameter of this portion of the canal to the size of a common quill. Its walls are more or less irregularly thickened and indurated by the cancerous deposit, so that they may measure half an inch, an inch, and even more. The portion immediately above the strictured part is commonly pouchy, and sometimes to such an extent as to contain two and even three lbs. of aliment unable to force its way into the stomach. In general superficial ulceration has taken place at the

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surface of the mucous membrane, and in a few cases the ulcer burrows in its usual manner, till at length it has perhaps perforated the larynx or trachea, and the patient falls from the aliment escaping into the bronchial tubes, or into the cavity of the chest. The quantity of food which reaches the stomach in these cases is extremely small, so that the patient's hunger is never satiated; and probably from this continued irritation the stomach presents some remarkable appearances; being, for the most part, small, thin, and of a dark, dirty, rusty brown colour; appearances similar to those found in the stomachs of destitute and famished patients. In some few instances, when the disease more principally affects the posterior portion of the œsophagus, the bodies of the vertebræ have become infiltrated with the cancerous matter, and Chardel mentions a case in which they were so softened that he was able to cut them with a knife.

Cancer of the *stomach* may embrace the whole extent of this organ, or any part of it. More usually, however, the affection is partial, and the parts most commonly affected are the orifices,—the frequency of the attack falling, 1st, on the pylorus, or the orifice connecting the stomach and duodenum; 2ndly, the cardiac orifice, or that which connects the stomach with the œsophagus; and lastly, on the body of the stomach.

When the orifices are the seat of cancer, they are constantly found contracted, but not closed, so that they appear to be in a state of permanent patency, the canal often not exceeding in diameter that of a quill. The walls of the orifices are often greatly thickened, the cancered portion varying from a few lines to a large tumor. In general, when the orifices are affected, the cancerous deposit stops suddenly at the commencement of the duodenum or œsophagus; but sometimes it extends a considerable distance along these canals. The pylorus being affected, the stomach is often much dilated.

When the body of the stomach is affected, the greater curvature is its most frequent seat. The cancerous formation is of varied thickness, as in other parts, but it does not form those large masses which are seen at the orifices; while, in extent, it varies from the size of an inch to the palm of the hand, and even sometimes embraces nearly the whole stomach. In these cases we find the muscular fibres in the opposite states either of hypertrophy or of atrophy; for, in some instances, they form fasciculi of great size, or as big as a wheaten straw; while, in other specimens, we are not able to discover in the midst of the thickened and indurated cellular tissue more than a few discoloured, attenuated fibres, separated by wide intervals. The cancerous degenerescence is not always limited to the stomach, but often extends to the glands situated on its edge; and then enlarged lymphatics can be traced sometimes to the mesentery, whose glands are also often enlarged.

In whatever part of the stomach the disease be seated, the patient often survives till the cancerous portion ulcerates, with its usual terrific characteristics, first superficially at its mucous surface, but afterwards perhaps penetrating between the lobules of the diseased structure till it reaches the peritoneum, which, rupturing, the patient dies of peritonitis. Sometimes the greater curvature of the stomach adheres to the colon, and then these parts may ulcerate into each other, so that the contents of the stomach may pass into the colon, or the contents of the colon into the stomach, and fæcal matter be thus thrown up by the mouth. Adhesions have also been seen formed between the stomach and the liver, or the stomach and the spleen; and those viscera have been extensively destroyed. Also, when the body of the stomach has been affected, the gastric artery or vein has become involved in the disease, has ulcerated and ruptured, and the patient has died from profuse hæmorrhage. Again, when the cardiac orifice has been the seat of the disease, that portion of the stomach has adhered to the diaphragm, and its contents have passed into the cavity of the chest. In general, in whatever portion of the stomach the disease be situated, the sound portion of the mucous membrane is usually found coated with a blackish or chocolate coloured mucus.

The *small intestines* are very rarely indeed found to be the seat of cancer. Chardel, however, mentions having seen them thickened and in a cancerous state throughout their whole extent. Much more frequently, however, only a small portion of the intestine is affected, as two or three inches, which becomes thickened and contracted so as hardly to admit the passage of a damson stone. This portion pursues the usual course, sometimes ulcerating before the death of the patient; and sometimes rupturing into the peritoneum, and destroying the patient.

The *colon* is more frequently affected with cancer than the small intestines; and although the cæcum and rectum, according to the usual law of the orifices being the usual seat of the disease, are the parts most frequently affected, yet it also often occurs in the more central parts of this intestine. This disease, as in the hollow organs generally, always occasions contraction; so that we constantly find the diameter of the gut reduced in these cases, and oftentimes so much so that a substance of the size of a pea can hardly pass. In the instance of the celebrated Talma, the intestine was contracted almost to obliteration. This obstruction to the course of the fæcal matter causes it to accumulate, and to such an extent that the superior portion often becomes enormously distended, almost to bursting. Many pounds weight, or many gallons by measure of fæcal matters have often been taken from it. The walls are thickened to the usual manner, and very frequently ulcerate at the mucous surface, and the ulcer, from the irritation to which it is exposed, often assumes a hideous character, ruptures the intestine, and the patient dies of peritonitis. The extent of the cancered portion is in general not more than a few inches, but Bouillaud has seen nearly the whole extent of the intestine schirrous.

When the *rectum* is the portion of the colon affected, the cancered part is often enormously thickened from the quantity of loose cellular tissue which surrounds it being filled with the cancerous deposit. The disease may begin at the anal extremity, or it may commence at the sphincters, or at two, three, or more inches above them. At whatever part, however, it begins, it has a tendency to spread upwards and downwards; and even all the left portion of the transverse colon has been involved in it. In proportion as the disease proceeds, the canal becomes contracted, so that the fæcal matters are either passed with difficulty in a fluid state, or, if solid, are as thin as a ribbon. The disease at length ulcerates; and the ulcer, if possible, is of a more than usually frightful character, having the hard inverted and everted edge, a hard fungoid bleeding base, and penetrating deeply, so as often to perforate the bladder in the male, or the bladder and uterus in the female, and from these causes

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the fæcal matters may pass forwards, and the urinary secretions backwards. The patient seldom long survives the sad suffering this state of things produces.

The *bladder and ureters* are sometimes the exclusive seat of this disease, and the affection, though in a few instances general, is more commonly partial. Its characters are nearly the same in the incipient state as in the stomach, and the organ may be dilated or contracted, and its muscular coat atrophied or hypertrophied. When the disease ulcerates, it often involves the rectum or uterus, or both, so that the three cavities all communicate with each other. Cancer of the *ureters* is rarely primitive, but it frequently follows the cancerous affections of the bladder. In this case the inferior portion of these conduits is the part most commonly affected; and as this contracts, the part above is sometimes enormously dilated. Besides the ureters, the *prostate*, situated at the neck of the bladder, is frequently affected, and perhaps more so than the bladder itself. This gland, in its natural state, is about the size of a chesnut, but, when affected with cancer, it is greatly enlarged, oftentimes acquiring the size of an egg. The urethra of this portion contracts, and is now so winding or irregularly conformed, that the passage of the urine is always difficult, and sometimes suppressed, and the introduction of the catheter almost impossible.

Cancer of the *uterus* is one of the most common affections of that organ after the cessation of the menses. The neck is its most usual seat, and its posterior rather than its anterior lip. In the schirrous stage it is hard, knobbled, unequal, and its orifice irregular and half opened; while, if ulcerated, the ulcer is superficial, its edge rarely raised, or its base hard. In general the body of the uterus, a few lines above the cancered portion, is perfectly healthy, but the superior portion of the vagina usually participates in the disease. In a few instances the body of the uterus is alone affected with the cancerous deposit, and is alone the seat of ulceration. The patient sometimes dies after a very trifling ulcer has formed, sometimes not till after the almost total destruction of the uterus, and in a few instances not until the uterus, bladder, and rectum form one large ulcerous cavity.

Such is a short outline of the pathology of hard cancer, as it is generally seen by the physician.

*Symptoms.*—Hard cancer, in whatever organ situated, has three stages. In the first stage the part affected is hard, slowly enlarges, and has its functions impaired. At first all this goes on without pain; but as the disease proceeds, severe paroxysms of pain, or severe lancinating pains, are felt in the part, although at long intervals. The frequency of these pains increases; and the second stage is marked by a greater frequency and severity of the paroxysms, till they are at last induced by every action of the part, while in the intervals the pain is constant or nearly so, though bearable. In the last stage, or after ulceration has commenced, the pain is incessant, often amounts to agony, and is only terminated by death. The duration of each of these stages is very various. The first stage is always the longest, and may last several months, or even years. The second is always more rapid than the first, and the third than the second. The symptoms of all these stages are principally local, as the patient rarely suffers from fever except in a very few instances, and only then in the very last periods of life. He is, however, often greatly emaciated and enfeebled.

Cancer of the *tongue, mouth,* and *pharynx,* are demonstrable to sight, so that the existence of the disease is palpable. The symptoms are those which have been stated; or, first, the functions of the part are affected, and the patient finds some difficulty in swallowing; this is followed by lancinating pains, which become more constant; at length ulceration takes place, which spreads, annoying the patient by the fœtidness of its secretion, till he ultimately falls exhausted by the discharge, and worn down by the ceaseless agony. The frequency with which the tongue is attacked is happily trifling, or, according to M. Leroy d'Etiolles, of 633 men affected with cancer only 18 had that disease of the tongue, while, of 2148 cancerous women, only 2 suffered in that organ.

Cancer of the *œsophagus* being out of sight, its existence is more difficult to determine. The first stage of this malady is marked by some difficulty in deglutition, followed at long intervals by occasional severe paroxysms of pain or colic, often referred to the stomach. The disease proceeds, the difficulty of swallowing augments, the paroxysms are more severe, and some pain or uneasiness is felt in the intervals. The patient is now constantly spitting a thick viscid phlegm, and in the last stage he throws up his food, and at intervals after eating, which are supposed to vary according as the cancerous stricture is situated high up or low down in the œsophagus. When, for instance, the food is returned as soon as swallowed, the obstruction must be high up; if lower down, a longer period elapses; and when the lowest portion, or towards the cardiac orifice is affected, the matters swallowed often remain for six, twelve, or even twenty-four hours, when they are thrown up unchanged, or only mixed with mucosities, the pouchy state of the superior portion of the œsophagus enabling it to retain a large dinner. As little passes into the stomach, the patient eats with great appetite; but notwithstanding this large supply, he becomes daily more and more emaciated, and at length dies with a feeble slow pulse, and a collected mind, worn to the bone by hunger and by frequent attacks of pain.

The first stage of cancer of the *stomach* is marked by frequent attacks of indigestion, and occasional paroxysms of gastric colic. The patient also loses flesh; his countenance becomes sallow, and he is evidently out of health.

In the second stage the pain recurs more frequently; pressure on the epigastrium increases it; and the suffering of the patient after eating is so great, that he is led greatly to diminish his usual quantity of food, and to lower its quality. At length digestion terminates, when the pain ceases for a time and he is once more at ease. In the midst of this deranged state of digestion, the appetite is good, often greatly increased, and there is a strange contest between the desire of eating and the terror the patient feels at indulging his appetite. His bowels are constipated, his tongue clean, his pulse quiet, and he is without fever, but his emaciation denotes the inward disease under which labours.

The last stage, or when ulceration of the stomach has taken place, is denoted by the purulent nature of the matters vomited, and also by the fæcal dejections being insupportably fœtid. Under these circumstances the strength of the patient is rapidly exhausted, some delirium ensues, and the patient dies either with or without diarrhœa. It is singular that death is often pre-

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Elementary Principles of Medicine.

ceeded by an entire cessation of suffering, as if the stomach had lost all power of re-action. In other cases vomiting of blood closes the scene, some large vessel of the stomach having ruptured; or else the patient dies of peritonitis, the ulcer having penetrated the cavity of the abdomen.

It is generally supposed that when the cardiac orifice is affected, pain immediately follows the effort of swallowing, and that vomiting takes place a few minutes afterwards. Again, if the body of the stomach be affected, that there is no difficulty in swallowing, while pain follows immediately from fruitless efforts at digestion, and vomiting some time afterwards. Lastly, that when the pyloric orifice is affected, that there is no difficulty in swallowing; that digestion proceeds, and that the pain and vomiting are delayed till the chyme attempts to pass into the duodenum. These phenomena, it must be admitted, are sometimes observed; but the difference of nervous sensibility is so great in different individuals that the rule cannot be relied on.

Cancer of the *small intestines* is so rare that few cases have been recorded of it. In a case which occurred some years ago in St. Thomas's Hospital the patient complained of great pain in the region of the liver, which was relieved by pressure, and of so severe a character that it was mistaken for the passage of a gall-stone. In three or four days the pain subsided, and the man shortly afterwards left the house. He continued well for about a twelvemonth, when he returned a second time to the hospital with exactly the same symptoms. The paroxysms, however, instead of subsiding, returned daily for many weeks. Indeed he had no ease unless he was constantly purged, and with these symptoms he shortly died.

When the *large intestines* are the seat of this form of cancer, the symptoms vary in some degree according to the seat of the disease. If the cœcum be the cancered portion, the symptoms in a great measure resemble those which have just been mentioned. When, however, the more central parts of the colon are affected, the opportunity for the accumulation of fæcal matter behind the stricture is greatly increased, and the patient, though he has longer intervals of ease, has severer attacks of pain in the bowels, aggravated by long constipation, having at first only three or four stools a week, then once a week, or once a fortnight; and Dr. Baillie gives a case in which nearly fifteen weeks elapsed without any evacuation. In this case the colon was so distended, that its transverse diameter measured above six inches; it contained a large quantity of fæcal matter, which, notwithstanding the long time it had been retained, was of a healthy character.

If the cancer is seated in the rectal portion of the colon, the first symptom is often an irritable state of the bladder; and this is followed by attacks of constipation and colic as severe, perhaps, as in the former case. If ulceration takes place, the devastation is often terrible, a communication being often formed between the rectum and bladder in the male, or between the bladder and uterus and the vagina in the female, and the patient dies from intense suffering, little relieved by our most powerful medicines.

The symptoms of cancer of the *bladder* or *prostate* are, pain and irritability of that organ, an irresistible desire to pass urine, and which, when effected, is accompanied with great pain. The urine, also, is loaded with mucus, and this secretion otherwise deranged. The prostate may be determined to be affected by the difficulty of passing the catheter, and by its increased size, causing it to project into the rectum.

The cancerous affections of the *uterus* are lumbar pains, pain on pressure above the pubis, difficulty of making water, and a fœtid discharge, mixed with blood. This disease may be made manifest to sight by means of the speculum. The examination by "*le toucher*," is liable to endless errors.

*Diagnosis.*—Cancerous affections may be simulated by many nervous disorders, and also by chronic inflammation of the respective parts; but the long continuance of the symptoms, their gradual augmentation, the severe pain which admits of no permanent relief, together with the loss of health and slow emaciation of the party, at last give a moral conviction that it must be cancer, and no other disorder.

*Prognosis.*—Cancer, though long latent and its course slow, pursues its destructive progress unimpeded, and in no instance does amendment or a return to health await the patient, who ultimately falls an inevitable victim to his complaint.

*Treatment.*—No remedy has yet been found which can in any degree be considered curative of cancer, and the efforts of the practitioner are consequently limited to relieving symptoms, and to the adoption of such palliative measures as may prolong life.

In whatever part the disease may be situated, one great rule is to endeavour to restore the healthy functions of that part by purgatives or other medicines, and to alleviate the distressing pains the patient endures by opiates. These remedies are for a time successful, but make no impression on the disease, which silently proceeds, and the patient finally limits himself altogether to opiates. The quantity of opium or other narcotic which the patient has been known to take is sometimes enormous, as five, ten, fifteen, or twenty grains of opium at a dose, or a proportionate quantity of hyoscyamus or of conium, exhibited three, four, or more times in the twenty-four hours. Dr. Powel used, however, to mention instances in which these large doses had been given with impunity for a long time, when most unexpectedly the patient had died narcotized, and apparently from merely changing the parcel of the medicine, either from some great difference in its strength, or else from its possessing qualities differing from those of the original parcel. He therefore always advised that, on having recourse to a new parcel, the dose should be reduced. But although these large doses have occasionally been given, yet it may be questioned whether they are not more hurtful than beneficial; for usually they produce headache, delirium, loss of appetite, and narcotism, so that the patient is only the more rapidly exhausted. In general, therefore, the patient does better under moderate doses of opiates, as one or two grains of opium, or its equivalent of morphine, or other narcotic, every eight, six, or four hours, than when more excessive doses are given,—a larger dose producing headache and much cerebral disturbance, without in any sensible degree mitigating the sufferings of the patient.

When the disease is seated in the colon, the quantity of purgative medicine necessary to produce a motion is often quite extraordinary. Dr. Baillie gave to a man labouring under this complaint five grains of calomel and ten grains of gamboge, but without producing even an attempt at evacuation by stool. This was followed up by a scruple of calomel and half a drachm of jalap, but even this was equally unsuccessful. Two

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drachms of gamboge were thrown up and quickly evacuated, but without being accompanied by any fæcal matter. On the following day another enema, containing three drachms of gamboge, was administered, but without any greater effect. Tobacco smoke was also injected in vain; the patient was then directed to take four grains of elaterium, but this made him sick without producing any evacuation by stool, and he afterwards swallowed three ounces of quicksilver, but without any result. As adjuvantia, electric sparks were sent through the abdomen, cold water dashed on the feet, a candle was passed up the rectum, but all were equally vain.

When the stomach is so irritable that it rejects everything, it is our duty to support the patient by nutritive injections, as of strong broth, egg-flip, of sago, or other fluid substances. It has been attempted to impart strength to the patient by means of milk baths, or baths of strong broths; but the skin has not any sufficient power of absorption, so that it has been found the heat of the bath has exhausted the patient in a far greater ratio than its nutriment supported him.

As a general principle, diet has no influence over the course of the disease, so that whatever agrees with the patient may be safely indulged in.

### Of Carcinoma Molle, or Soft Cancer.

Soft cancer differs from hard cancer in affecting organs rather than tissues, in being generally deposited in masses, and but rarely infiltrated. It differs also from it by the products of the softened or second stage being most profuse, and by its course being much shorter, this disease being generally terminated in a few months.

*Remote Causes.*—The remote causes of this affection are equally inexplicable with those of hard cancer, but the peculiar disposition once formed, changes of temperature and accidental injuries are its most usual exciting causes.

*Predisposing Causes.*—Hard cancer for the most part affects persons in the decline of life, but soft cancer is most common in its earlier period. Thus soft cancer of the eye, and of the jaw, is often seen in children. While soft cancer of the long bones, of the liver, of the lungs, of the peritoneum, &c., is most common in adult age, or from 25 to 40. This disease affects both sexes, and perhaps in nearly equal proportions.

*Pathology.*—Soft cancer is generally deposited in masses, but it may be infiltrated; the former is the more common form, the latter rare. In whichever form, however, deposited, it has two stages, or a stage of induration and a stage of softening. If we examine a soft carcinomatous tumor in the first stage, we find it composed, as in hard cancer, of cellular tissue and a morbid growth or substance. The cellular tissue is of various densities, often extremely fine, and then again of considerable consistency and tenacity, and in either case radiating through the tumor and dividing its lobules. The morbid substance or growth is of many degrees of hardness, or varies from lard to cartilage, but is generally softer than in the hard cancer; it is also of a bluish semi-transparent whiteness. The duration of this stage is from a few weeks to two, three, or four months, and only in a few instances does it exceed that latter period.

The first stage passed, the process of softening, or of *ramollissement*, takes place. The first evidence of this, according to Lobstein, is, that on cutting into the tumor, and passing the handle of the scalpel over the divided surface, a milky white substance is expressed. As the disease proceeds the parenchymatous substance is changed into the consistence of soft cerebral matter, or of thickened pus; it is consequently opaque, and varies in colour from white to red, and even black. These variations of colour appear to be owing to the different quantities of blood, or of melanic matter which are effused, and with which the cancerous matter is commixed. When bloodless, and therefore white, the product is so peculiar that it has been termed cerebriform, and, when mixed with blood, medullary sarcoma, fungus hæmatoides, and many other terms, according to the different quantities of that fluid effused, which is often so abundant that the cyst or cavity at length contains little else than fibrine.

The process of softening seems to commence indifferently in every part of the tumor, as at its centre, or towards its circumference; and if the tumor communicates externally the quantity of softened matter discharged often amounts to many ounces in the course of the day. This profuseness of discharge appears to be owing to the great vascularity of the tumor; for although in the hard stage only a few blood-vessels, with coats of great tenuity and delicacy, can be traced between the lobules; yet, in the softened state, a successful injection shows them to be made up almost entirely of blood-vessels.

The duration of the second stage is generally a few weeks, and very rarely a few months. It appears to be a law, however, that anything that greatly irritates the part accelerates the process of softening. Thus, if a cancerous limb or tumor be amputated, the cancerous matter primarily deposited in a hardened state is, subsequent to the operation, deposited in a softened condition, no previous hard stage existing. It would appear, also, that in a very few instances it is deposited in a softened state, independently of any operation; and there is a specimen in the museum of St. Thomas's Hospital of infiltrated soft cancer into the sub-mucous cellular tissue of the small intestines, which appears to be of this description. It was taken from a young man, who had carcinoma molle of several other organs, and in none of which were the tumors softened. The minute organic structure of this form of disease, in its schirrous state, is probably not dissimilar to that of hard cancer, and of its vital organic character there can be no doubt. Lobstein conceives that chemical analysis has shown the soft cancerous tumor in the first stage to be composed principally of gelatine, while in the second stage albumen is the principal ingredient. There is no ground whatever for conceiving this disease to possess any contagious property.

There is scarcely any organ or tissue in which soft cancer has not been found, and by some pathologists the frequency of its occurrence is supposed to be in the following order:—the liver, epiploica, the mesentery, the lymphatic glands, the brain and nerves, the spleen, the testicles, the uterus and ovaries, the eye, the bones, the heart, and lastly the blood-vessels. It has been stated that soft cancerous matter is far more frequently deposited in masses than infiltrated into these parts. In general there is only one tumor; but there may be, as is often seen in the liver, three or four, and in some cases they are extremely numerous. Dupuytren has met with a carcinomatous heart which contained more than 600. In size they commonly vary from a millet-seed

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to a large egg; but when they form in loose cellular tissue, as between the folds of the mesentery or of the epiploics, or in the substance of the lungs, they have been known to weigh 20, 30, 40, and even more pounds. These tumors may also be encysted or non-encysted.

One of the most constant features of this disease, and which distinguishes it from hard cancer, is, that it often appears in many organs or tissues at the same time in the same patient. Thus it has been met with in the coats of the bladder, in the liver, and in the lungs of the same party. Another law of this disease is, that it has a great tendency to be reproduced after an operation for its extirpation. This reproduction may take place either at the part operated on, or else in some organ or tissue distant from the primary seat of the disease. A cancerous tumor, for instance, having been removed from the armpit, others soon formed under the skin of the thigh and of the neck. In another case, a cancerous testicle having been removed, a similar tumor formed in the abdomen, and many small ones were found in the lungs and in the liver; circumstances which seem to demonstrate that soft cancer is a constitutional and not a mere local disease. These are the general laws of this disease; the pathology of its more particular instances are as follows:—

The scalp, the diploë of the skull, or the surface of the dura mater, may be each exclusively the seat of soft cancer; but more commonly all these three parts are simultaneously or consecutively affected; for if the disease begins in the scalp it often extends to the cranial bones, and from the cranial bones to the dura mater, and *vice versâ*. When the disease begins in the scalp the masses are often numerous, 20, 30, or more tumors being sometimes scattered over it. When, however, they form on the dura mater they seldom exceed two or three. In either of these cases the bone may be healthy, but more usually its cancellous structure is loaded with cancerous matter, interspersed with spiculæ of bone, the substance of the bone being soft and spongy.

Soft cancer of the *brain* is occasionally, but not often, met with. Andral has collected 43 cases, most of them recorded in different medical works, to which he has added some few observed by himself. Of these 43 cases the cancerous tumor was situated in 31 in the hemispheres, in 3 in the pituitary gland, in 5 in the cerebellum, in 1 in the mesocephalus, and in 3 in the spinal cord.

In cancer of the brain the patient generally falls while the disease is yet in the first stage, and before softening has begun. The size of the tumor varies greatly; for in some cases it is scarcely bigger than a nut, while in others a large portion of an entire hemisphere has been converted into cancer. The number of the cancerous tumors also greatly varies; in general there is only one, while in some cases there are many, occupying different parts of the brain. Around the cancerous masses the substance of the brain is found sometimes healthy and sometimes softened, while serum for the most part is found effused into the cavity of the arachnoid.

Among the forty-three cases mentioned by Andral, there were ten in which cancer affected other organs as well as the brain. In some of these instances the affection of the brain was primary, but in others it was consecutive to that of other organs. In one instance it appeared to follow the removal of a cancerous testicle, the patient up to that period not having shown any symptoms of disease in any other part of the body; but shortly afterwards he wasted and died, and on examination, enormous cancerous masses were found in the mesenteric glands, in the liver, spleen, lung, and brain.

Soft cancerous tumors form not only within the cranium, but also within the *rachidian canal*. Lecat gives a case in which a carcinomatous tumor destroyed the spinous processes of the four first lumbar vertebræ. Olivier speaks of having met with many examples of cancerous tumors developed in the rachidian, dura mater, and also between the pia mater and arachnoid. In one the tumor weighed no less than eight ounces; and by its pressure, the fifth, sixth, seventh, and eighth dorsal vertebræ were absorbed, so that it presented itself externally. The same authority also gives the following instance of carcinomatous affection of the *substance* of the *cord*. The patient was a widow, aged thirty-six, who died after two years' illness, and on opening the spinal canal, a fungous growth was seen covering the whole anterior surface of the cord from the sixth cervical to the third dorsal vertebra; it was under the arachnoid, and appeared to be incorporated with the substance of the cord.

Soft cancerous tumors sometimes form in the *substance* of the *nerves*, and sometimes on their *neurilema* or coat. Sir Everard Home met with one of these tumors in the musculo-cutaneous nerve, of the size of a small pullet's egg; M. Dubois, one on the median nerve; and Dupuytren, one on the posterior tibial nerve; while in another case he found the trifacial nerve transformed into a cerebriform substance.

Soft cancerous matter is sometimes infiltrated into the tissues of the eyelid—its seat the free edge, or else the commissures of the eyelid. When the external commissure is affected, the disease often begins with a painful fissure with a grey base; an ulcer at length forms, which spreads with edges inverted and averted, often destroying the whole of the eyelid and other portions of the face. Cancer of the internal commissure begins generally in the caruncula lachrymalis, which is swollen, hard, schirrous; this at length ulcerates, and either so compresses or involves the lachrymal duct, that it is accompanied by a continual discharge of tears, or a "watery eye."

The cancerous deposit may be *infiltrated* or formed into *tumors* in the *eye*. This disease sometimes begins in the conjunctiva, which becomes fungoid, hardened, and disorganized. In other cases it takes place among the laminæ of the transparent cornea, which ulcerate, and the ulcer having an elevated edge and a schirrous base, invades the surrounding parts. Again, the cancerous formation may affect the deeper-seated membranes, and more especially the retina and choroid membrane; and in these cases a tumor forms, which thrusts the eye out of the orbit, displaces the vitreous humour, dislocates the crystalline lens, and impairs the action of the iris, and these parts afterwards ulcerating, the sight is shortly destroyed.

Soft cancerous tumors occasionally form in the cellular tissue of the *orbit*. The majority of these tumors are of rapid growth, of a soft medullary structure, and are quickly reproduced if removed. They are of such magnitude that in most cases the eye protrudes in a most unsightly manner, while vision is impaired or wholly lost by the pressure and extension of the optic



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nerve. But although the eye is often displaced to a great extent, yet vision is sometimes preserved. These malignant tumors are most frequently met with in childhood, though they may occur at all periods of life. In the majority of cases similar tumors co-exist within the cranium along the optic nerves, or in their tract behind the commissure, extending to the optic lobes, and even to the cerebellum.

The different structures of the *face* and *mouth* are also often the seat either of soft cancerous infiltration or of cancerous tumors. Thus we often find intractable infiltrated ulcers of this description of the integuments of the nose, of the cheek, and of the mouth; or, of 633 cases of men affected with cancer, 165 had cancer of the lip, while of 2148 women, only 54 had this affection of the lip, a difference which M. Leroy d'Etiolles conceives results from the greater use of the pipe among men, and especially of the short broken pipe, which the French term "*brûle gueule*." The cavities of the facial structure are also the seat of cancerous tumors, which give rise to great deformities. These growths often commence in the sinuses connected with the cavity of the nose, show themselves from the nostrils, protrude through the orbit, and get into the mouth behind the palate, through the tuberous processes of the superior maxillary bone, or project through the alveolar processes. Sometimes, though rarely, these tumors form in the frontal sinuses, or sprout from the antrum. The parotid gland is also occasionally the seat of this affection, and is the more formidable from its connexion with the carotid artery.

The alimentary canal is occasionally the seat of soft cancerous infiltration, or else of tumor. These tumors have often been found in the *stomach*. A woman, previously in perfect health, died at the Hôpital Cochin of a fractured thigh; she was opened, and four cancerous tumors were found at the posterior face of the stomach. Andral also met with a large cancerous tumor in the stomach of a young man aged twenty-two. In the Museum of St. Thomas's Hospital there are two specimens of these large cancerous tumors of the stomach, which occurred in the practice of Dr. Williams. The patient generally dies before ulceration takes place, but should he survive that result, the ulcer is usually of a most irregular and hideous character.

The soft cancer does not appear to exist nearly so frequently in the intestines as in the stomach; and, as has been stated, there is an almost unique specimen of infiltrated soft cancer in the coats of the small intestines in the museum in St. Thomas's Hospital.

Soft cancer of the *liver* is by no means unfrequent, yet Cayol conceives that previous to 1833, when he described it, no account of it existed. The pathological phenomena of this disease are, that on opening a patient that has died of soft cancer of the liver, we observe the surface of that organ marked with one or more slightly projecting tumors covered by the peritoneal coat. These are white, opaque, and slightly depressed in the centre. When the liver is cut into we often find others less superficial; so that their number varies perhaps from one to five or six, or even more, while in size they vary from a pea to an orange. In some instances the liver appears infiltrated with this substance, so that it occupies three-fourths of a lobe.

The patient usually falls while the tumors are yet in the schirrous stage, or semi-transparent, radiated, and of a moderate hardness. In the greater number of cases they are enveloped in cellular tissue, and can readily be dissected out with the handle of the scalpel, when a perfectly smooth cavity is left; but in other instances there is unquestionably continuity of tissue between the liver and these tumors. If the patient survives this stage, the first step towards softening is the appearance of a few blood-vessels penetrating between the lobules, and perhaps a slight effusion of blood in the centre of the tumor. This is followed by a gradual conversion of the cancerous matter into a cerebriform substance, and which proceeds till the whole is so broken down as to form a sort of abscess, which may burst into the peritoneal cavity, into the stomach, the duodenum, or colon. It is singular, says Cayol, that the secretion of bile is little interrupted, even in those cases in which large portions of the liver are affected, for the bile in the gall-bladder is not sensibly altered either as to quality or quantity. The substance of the liver also around the tumor is healthy. The jaundice, which sometimes, but by no means constantly, accompanies this affection, Cayol considers to depend on the pressure made by the tumors on the gall-ducts. Besides cancer of the liver, Bouillaud has seen a schirrous state of the gall-bladder, and he also mentions having met with a cancerous tumor, of the size of an almond, at the embouchure of the hepatic veins at their junction with the cava.

Soft cancer of the *pancreas* is by no means common; for although many patients who die of cancer of the stomach or liver have cancerous masses more or less considerable in the neighbourhood of the pancreas, yet when the latter viscus is examined it is generally found without alteration. Primary affection of the pancreas is still more rare; and only a few cases have been met with out of many thousand bodies examined. The celebrated President, De Thou, however, is supposed to have died of this disease. Dr. Bright, in the 18th volume of the *Med. Chir. Transact.* has given some instances of malignant disease of this viscus. Mr. Mayo has also given a case in which the pancreas was considerably enlarged, and of nearly cartilaginous hardness, except some spots, which were soft, with the appearance of medullary sarcoma. A case also recently occurred, in which the pancreas, besides being enlarged, was softened and red in consequence of the large quantity of blood which had been effused.

The soft cancer of the *spleen* is rare, and its characters not well understood. Two cases, however, lately died in St. Thomas's Hospital with dropsy and enlarged spleen, and on examining them a reddish broken-down tumor was discovered in each of their spleens, and which appeared to be soft cancer, modified perhaps by tissue.

Soft cancer of the kidneys is more common, and in the hard stage presents all the characters which have been remarked as occurring in the liver. But the kidney acquires a greater size, and has been said to weigh as much as 40 lb. when thus diseased. One case is given, in which the vena cava was obliterated by its pressure. When the disease passes to the softened stage, the product varies greatly in character; sometimes the tumor being converted into a white cerebriform matter, and sometimes filled with pure fibrine—differences which are probably owing to differences in the quantity of blood effused.

The *bladder* is sometimes the seat of soft cancer, and which may be infiltrated or formed into masses. More commonly it assumes the form of fungous vegeta-

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tions projecting into the cavity of this viscus, and sometimes entirely filling it. A case of this description occurred to Bouillaud, at La Charité, in 1828. The tumor was as large as the fist, and resembled a cauliflower excrescence, and filled the entire cavity of the bladder; and a similar but less formidable case occurred recently at St. Thomas's Hospital.

The *uterus*, like other organs, is occasionally the seat of this disease. It may be infiltrated or formed into masses, but the former is the most common. In the schirrous stage, these tumors are not so transparent as those of the liver, but more resemble lard, and generally occupy the body of the uterus. They are of various sizes, or from a pea to a small egg. When infiltrated it is most generally the neck of the uterus which is diseased, and the ulcer which follows has generally a soft base and a smooth edge.

Bayle and Cayol question the existence of soft cancer of *the ovary*; but in women of a "certain age," says Bouillaud, this disease is not rare, and he gives a case in which the two ovaries were so enlarged as to meet; the left ovary being the size of an ordinary liver, and the right that of a fœtal head. M. Maingauli has communicated to the Académie Royale de Médecine, a case in which the ovary thus enlarged weighed 60 lb.

A more common seat of soft cancer is the folds of the *mesentery*, and the tumors which here form are of the largest magnitude—the cancerous formation sometimes occupying the whole of the abdomen, so that the party, if a female, is often larger than at the most advanced periods of pregnancy; or, if a male, has the appearance of one labouring under ascites. These tumors present no novel appearance; they are lobulated, and extremely vascular. The patient usually falls before they soften, but occasionally he survives till after that period, when the different lobules may be seen in every stage and degree of hardness and of softening. In most cases, however, these tumors form adhesions to the walls of the abdomen, and in a few instances ulcerate, so that the tumor softens and bursts externally, when the discharge is generally enormous, and rapidly destroys the patient. It is remarkable that, on examining the bodies of patients who have died in this state, we often find considerable quantities of the softened cerebral matter in the larger blood vessels, and also in the cavities of the heart.

Soft cancer of *the lung* was perhaps first pointed out by Bayle. It presents itself under two different forms—of masses and of infiltration, and may be complicated with tubercle or other disease of the lung. Bouillaud much over-estimates the frequency of this disease when he states, that out of 200 cases he found four of pulmonary cancer. He gives the case of a young girl with cancer of the lachrymal duct and carcinomatous polypus of the nose, in whom the superior lobe of the lung was transformed into one compact lardaceous mass, of a yellowish white, and without a trace of blood-vessels or nerves. It was not softened, and some large bronchial tubes not obliterated could be traced through it. In another case, the entire lung was converted into a cancerous mass, in the substance of which some pulmonary vesicles could be distinguished, though atrophied. The bronchial glands are also occasionally the seat of this affection.

Cancerous masses of greater or less size are sometimes developed in the subjacent *pleural cellular tissue*. In a case given by Velpeau, four cancerous masses existed between the ribs and the pleura. In a case also that recently died in St. Thomas's, a mass of serous cysts, as big as a large apple, and adherent to the false ribs, had become the seat of cancerous deposit. It is in the cellular tissue of the mediastinum, however, that cancerous masses more often form, and sometimes so large as to compress the aorta, vena cava, pulmonary artery, or phrenic nerves. Dalmas has seen the superior vena cava obliterated from this cause. In other cases they cause absorption of the bones of the sternum, and form a projection of considerable extent under the integuments. Bouillaud has seen one which was mistaken for aneurism of the aorta.

Soft cancer of the *heart* appears to have been first described by M. Carcassonne, in the *Memoires de la Société Royale de Médecine*, in 1777-8, and it has since been seen by most pathologists. In one case given by Laënnec, there were several cancerous masses about the size of a nut in the muscular substance of the ventricles; while in another it was deposited in layers one to four lines thick along the coronary vessels, between the pericardium and the heart. Also in a case by Trélat, the walls of the right ventricle were an inch and a half thick from infiltration of cancerous matter, while the septum aurienli was transformed into a schirrous mass an inch and a half thick. The septum ventriculi was likewise in a cancerous state. Velpeau also gives a case in which the walls of the heart contained about a dozen cancerous masses of various sizes, the biggest being as large as a pigeon's egg. Sometimes the *pericardium* has been found involved in the disease. Cancer of the heart has rarely been seen, except when similar disease has existed in other parts of the body.

Cancer *mammarum* rarely attacks the male, but is almost peculiar to the female. It is scarcely ever seen before 20, sometimes between 20 and 30, more frequently between 30 and 40, but is most common from 40 to 55. From the age of 60 to extreme old age it becomes more and more rare. Its usual course is as follows:—

A woman, on touching her breast, discovers a small tumor or hardness, which causes her so little inconvenience that she neglects it. The hardness augments and the tumor increases, and though at first perhaps not bigger than a nut, reaches the size of a duck's egg. At first it was round, circumscribed, and moveable under the finger, but at length its surface becomes unequal and knotted, as well as adherent to the skin or muscle. It may still, however, be handled without pain or suffering, but is the occasional seat of lancinating pain. The disease increases, the surrounding cellular tissue becomes infiltrated with the cancerous deposit, and the lymphatic glands of the armpit become enlarged. The tumor is at length salient; the skin covering it red or livid; the nipple sunk and depressed; and, at last, the skin cracks. This crack or chap enlarges into an ulcer, which burrows in every direction, whose edges are thickened and everted, and which discharges a copious and fœtid sanies, and at length frequent hæmorrhage takes place. The disease pursues an unmitigated course; and at last the patient, worn out by incessant suffering, and exhausted by a constant discharge, gladly resigns a life so long embittered. Such is the more ordinary course of cancer of the mammæ; but this disease has endless varieties, both in its progress and in the nature of its discharge, which our limits prevent us from describing.



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*Symptoms.*—Soft cancer, when the tumor has space to enlarge, forms and runs its course, with a few exceptions, without pain. In the close cavities, however, as the brain, the patient's sufferings are often severe from the pressure the tumor produces on the nerves. Cancer of the mammæ and testicle is of a more mixed character, and the latter stages of the disease are often accompanied with great suffering.

When cancerous tumors form in the *scalp*, the patient suffers no pain, but ulceration at length takes place, and the patient falls from hectic and exhaustion.

Soft cancer of the *brain* has no characteristic symptom. The lesions of the intellect are by no means constant or uniform. Indeed in by far the greater number of cases the intellect has continued unimpaired. In other instances, however, the mind has become obtuse; the memory impaired; and this has been followed by delirium, insanity, or epilepsy. Lesions of motion are also not more constant, and sometimes are altogether wanting. When they do exist, the result is a slow-coming palsy, affecting one or more limbs, as an arm or a leg; or the patient may be paraplegic or hemiplegic, with affection of the bladder. The palsy likewise may be complete or partial, confined to the extensor or flexor muscles, and therefore accompanied by contraction.

Lesions of sensation are likewise by no means constant; thus headache, although frequent, is not present in every case, and when present offers the greatest difference in intensity, being sometimes slight, so as hardly to be remarked, and at others so severe as to form the prominent feature of the disease. Its character also varies, being sometimes dull, and sometimes lancinating; sometimes constant, and sometimes intermitting. Neither does it always designate the seat of the disease, being sometimes general when the disease is very limited. The pressure on the brain likewise causes the pain often to be reflected. Thus, in some persons the pain is only felt in the arm or trunk, while others suffer from a singular sensibility of every part of the cutaneous tissue, so that the slightest touch is followed by the most excruciating agony, while in others the patient is annoyed by the most insupportable itching.

The functions of the senses have in some instances been impaired, whether the nerves have or have not participated in the cancerous affection. Thus some persons suffer a gradual loss of sight. In Dr. Wollaston's case, vision was so singularly affected that he was able to see only the latter halves of words. In another case the patient became so deaf and so blind that the only mode of conversing with him was by the fingers. While Andral mentions a girl who lost the use of every sense, as also of motion, although her intellect remained perfect.

It frequently happens that the general health is good till a very late period; but in other cases the patient is troubled with frequent vomiting, constipation, and retention or else incapability of holding his water.

When cancer forms among the meninges of the brain, as long as the cranium is imperforate, the symptoms are the same as those of the brain. When at length, however, the cancerous tumor has perforated the walls of the cranium, the pain perhaps ceases, but ulceration takes place, and death soon follows.

Nothing is more variable than the duration of cancer of the brain. Sometimes death takes place in a few months, while in others years elapse before the fatal catastrophe. In either case the patient may fall seized with convulsions, epilepsy, or coma, or else die exhausted from ulceration of the nates, sacrum, &c.

Cancer of the *vertebral column* is generally marked by paraplegia, incontinence of urine, numbness of the lower extremities, sloughing of the nates, and death. The palsy which results may be either complete or accompanied by contraction. In one woman, aged 52, during the period of four months, her limbs could not be flexed without producing most atrocious pain. At length her legs became contracted, and to such a degree, that the heels were in contact with the glutei muscles, and the knees with the chest, and extension was now as painful as flexure had been before. In some few instances, as long as the palsy is incomplete, the pain in the back is long continued and extremely severe, and accompanied by convulsive twitchings, which do not subside till the palsy is complete. The duration of this affection varies from a few months to two or three years.

Soft cancer also often forms superficially in the *subcutaneous tissue*, and is usually accompanied with similar forms of this disease in other parts of the body. The tumor thus formed, if removed by an operation, is almost always re-produced by a more rapid growth, and in a more softened state, and consequently runs a much quicker course than the original tumor. Soft cancerous matter is also frequently deposited in large masses, as well as infiltrated, into the *adipose* and *cellular membrane*, and also among the *muscles* and in the substance of the *bones*. Whenever the fungus comes in contact with the muscles, says Mr. Hey, they lose their natural colour and become brown. They also lose their fibrous appearance, and cannot in every part be distinguished from adipose membrane. The fungus as it increases in bulk does not render the integuments uniformly thin, as in the case of an abscess; but they continue to feel thick as usual, over the tumor which forms beneath them, and which at length ruptures them. When the bone is the seat of this affection it greatly enlarges, especially its cancellous structure, which becomes filled with cancerous matter, and, as the disease proceeds, the whole limb becomes more or less infiltrated with it.

Soft cancer of the *testicle* is not unusual, and its schirrous stage has no peculiarity. In the second stage the product is either a soft colourless cerebriform matter or a cerebriform matter streaked with blood, or else it may be the seat of more considerable hæmorrhage. The cord often participates in the affection, adheres to the pubis, and fixes the testicle there. The lymphatics and their glands often undergo the same degenerescence, and by their pressure have obliterated the large vessels with which they lie so nearly in contact. In the last stage the tunica albuginea ruptures, ulceration follows, and fungous growths springing from its base give rise to a foul fœtid discharge, accompanied by frequent hæmorrhage. The cancerous testicle has been seen to weigh seven pounds.

On examining the bodies of those who have died of soft cancer in its softened state, it is not unusual to find cerebriform matter in considerable quantity in the veins, and it may often be traced even into the cavities of the heart.

*Soft Cancer of the Periosteum.*—Mr. Frogly has given two cases of a whitish elastic hard tumor of

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the thigh resembling cartilage, but rather more transparent, and of considerable size, the diameter of one measuring 55½ inches. On cutting into it it was found to consist of numerous cysts containing several pints of a yellow tenacious honey-like fluid, and was evidently a serous cyst which had undergone cancerous degeneration. The second case was similar.

The cancerous tumors formed on the *nervous trunks* are ordinarily moveable, but very painful when touched, so that the patient for the most part willingly submits to an operation. If the operation be performed, as a portion of the nerve must be excised, the patient, as a consequence, necessarily suffers from a greater or less degree of palsy and insensibility of the parts to which the nerve is distributed.

Soft cancer of the *palate*, *mouth*, and *face* are seldom accompanied by pain, unless it results from pressure made on the surrounding parts.

In the stomach large cancerous tumors often exist without the slightest pain. A man, about 50, was admitted into St. Thomas's Hospital: he was greatly emaciated, and evidently out of health; but he ate heartily, slept well, had a quiet pulse, and made no complaint of sickness. A few hours before his death, however, he did vomit. On examining this patient a soft cancerous tumor, as big as the fist, was found in the stomach. In another emaciated patient, admitted for dropsy, there was no sickness, nor any complaint of pain; after death, however, a similar tumor was found in the stomach of this man. In another case, in which there was cancerous infiltration in the coats of the *small intestine*, none of the functions of the bowels were impaired.

The *pancreas*, from its close texture, perhaps gives more evidence of this affection; and the symptoms are, some pain in the epigastrium, vomiting, and headache, with great emaciation. Mr. Mayo, however, gives a case in which the patient took a good deal of food, and complained of nothing except a pulsative pain of the ear. The symptoms are consequently not constant; and unless a tumor can be felt, the diagnosis of this disease is still very imperfect.

Cancer of the *liver*, according to the general rule, is often void of pain. A patient was admitted into St. Thomas's Hospital with his mind greatly agitated, so that his friends were alarmed lest he should commit suicide. He complained of racking pains in all his limbs, which allowed him no rest, and which were considered to be rheumatic. The pains shortly subsided, but he did not recover his health, so that it was plain he was labouring under some structural disease, but of what nature could not be determined. On examining him after death, cancerous deposits were found in the liver, intestines, and heart.

The *spleen* has a similar exemption from pain in this disease; but the viscus enlarges, dropsy follows, and death is the consequence.

The *bladder* seems equally insensible. A patient laboured under ulceration and suppuration of the elbow-joint, and he shortly afterwards passed blood in his urine. Of this latter complaint he appeared to die; but, except an irritable state of the bladder, he suffered little or nothing in the vesical region. On examining him a soft cancerous tumor was found in the bladder.

Cancerous formations sometimes take place in the *lungs*, and yet it is impossible to distinguish the effection during life from phthisis, a disease in which there is no pain. A patient very recently died, in whom a cancerous tumor existed under the false rib; but, although troubled with incessant cough, his pulse was quiet, and he suffered no pain. Similar tumors have been found in the heart, not only without pain, but without any interruption of the circulation. The large cancerous masses which sometimes form in the duplicature of the mesentery or omentum are equally free from pain, and are frequently mistaken for ovarian dropsy, a disease whose greatest inconvenience is its bulk. The kidneys also have often attained a great size from cancerous deposit, and destroyed the patient without pain; the symptoms being, great emaciation, hæmaturia, attacks of suppression of urine, and perhaps dropsy. When the disease has formed externally, or among the muscles, there is likewise no pain. The patient assured me, says Mr. Hey, that he had walked without pain in his knee a week before his admission into the infirmary. These instances are sufficient to establish the general law of the disease being unaccompanied by pain, and that the inconvenience is generally local till ulceration or softening takes place. The duration of this disease, it has been stated, is very various, terminating in some cases in a few months, but in others lasting two or three years.

*Diagnosis.*—It is impossible to distinguish diseases depending on soft cancer from those caused by tubercle; but in parts where the tumor can be felt, its greater size, the greater *embonpoint* of the patient, and the general absence of hectic, afford in general a sufficient diagnosis between the two diseases. When the tumor cannot be felt, soft cancer can only be distinguished from the similar functional diseases it gives rise to by the intractable nature of the complaint, its slow but undeviating course, and, in a word, by a state of things which no ordinary derangement of the functions of an organ can account for.

But these are not the greatest difficulties in the diagnosis of soft cancer; for tumors occasionally form, as in Mr. Frogley's case, in the thigh, in the antrum, in the jaw, in the mammæ, and in other parts of the body, which simulate tumors in the first or schirrous stage of soft cancer, both in form, size, seat, and intimate structure, but which have no tendency to soften or to take on a *malignant* character. Ambroise Paré, Morgagni, and the earlier writers have spoken of tumors of this character; but Bayle is the first author who can be said to have treated expressly on them, and he has described them as fibrous *degenerescences* of the mammæ. He says these tumors, at first fleshy, at length become cartilaginous or osseous, but do not become *cancerous*. Sir Astley Cooper has described them as *chronic mammary tumors*, attacking in general young women between 17 and 30, but which have nothing in common with cancer, as the patient preserves her best health. He describes them as of extremely slow progress, superficial, moveable, and lobular in structure. Sir B. Brodie also admits the existence of these tumors, which he describes as feeling "like *schirrous*, and which on cutting into, it feels like *schirrous*, so that I can give no other name to it," and which has no tendency on being removed to return. Cruveilhier describes them as fibrous bodies, as varying in size from a millet-seed or a cherry to the head of an adult, as having no tendency to cancerous softening, or to be reproduced when amputated, and are not otherwise inconvenient than from their size and weight. He has met with them in old women of 80 and upwards at

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Elementary Principles of Medicine.

Salpêtrière, and in whom they had formed in early adult life. It is difficult to speculate on the comparative frequency of these benign tumors; but supposing cancer always to be reproduced after removal, the result of operations would give nearly an equal proportion of cancerous and fibrous tumors. But these data are probably unsure, and the subject is still open to much further and interesting investigation.

*Prognosis.*—This disease has in all instances proved fatal when an operation has not been practicable. The disease appears capable of being removed from the mouth with success; and the patient has survived amputation of the extremities, or its removal from a superficial position. The great majority of cases, however, have died, or else the disease has shortly returned and quickly proved fatal.

*Treatment.*—At present no remedy exists for this form of disease. Every general mode of treatment has signally failed, and its cure therefore depends on a specific medicine being discovered. The treatment in the actual state of medicine is, consequently, most unsatisfactory, and entirely palliative, or by opiates and attention to the general health.

If the patient lives moderately, diet appears to have little effect on the course of the disease.

### Order V.—Of Melanoma or Melanosis.

Pathologists have given this term to a morbid production of a black or brown colour. The disease was first described by Laënnec.* In 1821 he published some new instances of it, and since that period it has been more particularly studied by Dr. Carswell and MM. Trousseau and Leblanc. This affection is not limited to man, but occurs in the horse, especially when glandered, and is more common in the dappled grey than in that of any other colour. It has also been found in the dog, the cat, the rabbit, the rat, the mouse, and other animals.

*Remote Cause.*—The only clue we have to the possible causes of this disease is mentioned in Chossat.† In six frogs, whose deaths had been induced by a long inanition, or from nine to twelve months, the red blood had completely disappeared, and was replaced by a black fluid similar to a dilute solution of sepia or of ink, which filled all the vessels of the limbs, mesentery, lungs, and brain. But the organ which was more remarkably the seat of this general melanosis was the liver, whose hepatic colour was changed to black, and stained paper like Indian ink, and the stain was not effaced at the end of six years.

In the human subject the remote causes of this disease are little understood, and it occurs in so few instances that it appears connected with peculiarity of constitution rather than peculiarity of cause. One might imagine it was some local atrophy of the parts, did it not generally occur in greatly hypertrophied and otherwise diseased livers.

*Predisposing Causes.*—Andral met with a decided melanotic induration in the superior lobe of the left lung in a girl 9 years old; and Lobstein met with an instance in an old woman between 80 and 90. The most common period is between the ages of 30 and 50, and it is a disease which equally affects both sexes.

*Pathology.*—Melanoma, like cancer and tubercle, may exist as a tumor or mass, or may be infiltrated into the various organs and tissues of the body; and, lastly, it may likewise be deposited at the free surface of the mucous and serous membranes.

When melanome exists in masses, Laënnec has attributed to it two stages, or a stage of hardness and a state of ramollissement. In the hard stage the mass is of considerable firmness, so that it has been compared to suet, or to the substance of the lymphatic glands. The colour is generally of a soot-black, and it gives a stain to white paper or linen as deep as Indian ink; but in other instances it is of a yellowish-brown or bistre tint. In form the masses are sometimes spherical, sometimes irregular, and at others not like any geometrical figure. In size they vary from a millet-seed to a goose's egg; and Andral speaks of having met with tumors so enormous as to weigh thirty-six pounds. They are occasionally lobulated, and the lobules divided by cellular tissue. Laënnec considered that after an uncertain period the hard stage passed into the stage of remollissement, the tuber softening from its centre to its circumference, till at length the whole is converted into a black or brownish pulp or *bouillie*. He also thinks that the tumor having softened, ulceration may take place in the surrounding tissues, and the softened matter escape, as from an abscess, and the cavity perhaps ultimately cicatrize. Such is the course ascribed by Laënnec to melanoma. The fact, however, of the stage of ramollissement is disputed,—not that cysts containing fluid melanoma have not been met with, but because some pathologists conceive it may have been deposited in a fluid state.

Melanoma may be encysted or non-encysted; Laënnec has met with encysted tumors in the liver and the lungs; and Breschet has seen them in different parts of the cellular tissue. On the contrary, all the cases seen by Andral have been non-encysted, the tumor adhering more or less intimately to the surrounding tissues. Although neither nerves or blood-vessels have been traced into these tumors, Laënnec considered melanome to be an organized growth or tissue; but Andral is of opinion that it is a veritable inorganic compound, and if sometimes the seat of vital phenomena, that those are owing to the living membrane which surrounds or is imprisoned in the mass. Chemistry does not greatly assist us in this difficulty. It has merely determined the melanic matter to be inodorous, insipid, opaque, miscible with water or alcohol, and as putrefying slowly. It is essentially, according to Thenard, compounded of carbon; according to Clarion, of albumen and of a peculiar colouring matter; according to Barruel, of the colouring matter of the blood united to fibrine; and lastly, M. Foy has given the following analysis:—

| | |
|---|---|
| Albumen | 15·00 |
| Fibrine | 6·25 |
| The black principle, evidently carbonaceous or altered cruor | 31·40 |
| Water | 18·75 |
| Oxyde of iron | 1·75 |
| Sub-phosphate of lime | 8·75 |
| Hydro-chlorate of potash | 5·00 |
| Hydro-chlorate of soda | 3·75 |
| Carbonate of soda | 2·50 |
| Carbonate of lime | 3·75 |
| Carbonate of magnesia | 1·75 |
| Tartrate of soda | 1·75 |

* *Bulletin de l'Ecole de Méd.*, 1805. No. 2.
† *Sur l'Inanition*, p. 74.

Besides being deposited in masses, melanoma is often infiltrated into the substance of organs, as of the liver, or of the lungs, or into the web of the mucous and serous tissues, especially after chronic inflammation, as in dysentery. It is also often secreted at the free surfaces of the mucous and serous tissues in a liquid state. Thus, in chronic peritonitis, and especially if a false membrane has been formed, the surface is often coated partially or generally with a black fluid. Andral gives a case in which he collected fluid melanic matter in considerable quantity from the free surface of the mucous membrane of the small intestines. It follows, therefore, that melanoma may be deposited in a solid state either in masses or in a state of infiltration; and likewise that it may be deposited in a liquid state at the free surface of membranes. There is nothing to show that melanoma is of a malignant nature; at least it appears to constitute an integral part of the bronchial glands for an indefinite period, but without giving rise to any symptoms. It often exists in many organs or tissues at the same time, and may co-exist with either tubercle or cancer. After having thus stated its more general laws, we shall proceed to give a few particular instances of it in the different organs and tissues.

Dr. Halliday found melanic tumors of the *dura mater*, and Lobstein has seen melanosis of the *optic nerve* on the left side, the melanic matter having penetrated two lines deep into the substance of the *brain*. The man died of apoplexy. Chomel has likewise given an interesting case of melanic matter situated in the cellular tissue at the base of the *orbit*.

Cruveilhier has met with melanic tumors in the *stomach*; and Andral has observed them many times in the sub-mucous cellular tissue of the *alimentary canal*, their mean size being that of a nut, and their most common seat being the colon. It has been stated that melanic matter is often found at the free surface of the mucous membrane of the stomach and intestines. Some pathologists also consider the black vomit and also melæna to be of this character. It has also been found incorporated in the mucous tissues of the alimentary canal, giving it a grey tint. Melanic matter has also been found under the *peritoneum* in masses; likewise in a fluid state at its surface, and also incorporated in its tissue.

A splendid specimen of melanosis of the *liver* is to be found in the museum of St. Thomas's Hospital. It has been observed in all these liver cases that the liver is enlarged. Chomel met with a melanotic liver in a dancing-master which weighed 14 lb. 7 ounces. It contained masses varying from the size of an oat to a pullet's egg. The gall-bladder and ducts were nevertheless filled with bile.

The *lungs* are, of all organs, those which are most frequently the seat of melanosis, and the melanic matter appears often to exist in them without affecting, in any degree, their functions or the general health of the patient, so that it can hardly be considered in these organs as a morbid product, and hence it has been termed, *melanose naturelle*. It has been found in masses and in a state of infiltration at the surface, and in the substance, of the lungs. It is also secreted by the free mucous surface of the *bronchial membrane*, marking the expectoration. The *bronchial glands* are also often loaded with it, and similar tumors have also been found under the *pleura costalis*.

Andral has seen a patch of deep black, as broad as a two-franc piece, and from seven to eight lines in thickness, under the serous membrane covering the *heart*; and a similar case is related in the *London Medical Repository* for 1823. Breschet, moreover, met with an instance of melanoma among the muscles of the heart. Melanoma has likewise been found in masses in the coats of the arteries; and in one instance Andral found them as large as a pea and as hard as a calculus, and therefore perhaps mixed with phosphate of lime.

Rayer has met with melanosis of the *kidney*, the melanic matter being deposited in the cortical substance, and the substance around them healthy. In some few instances, the urine is passed almost of a black colour, leading to the supposition that these organs may secrete fluid melanic matter.

The *lymphatic glands* of different parts of the body are frequently the seat of melanosis. The bronchial glands, it has been stated, are often filled with this black matter, and, under these circumstances, are greatly enlarged. Enormous masses of melanoma have been found in the pelvis and before the vertebral column, forming a sort of chaplet, and which Andral conceives to be lymphatic glands. It has likewise been found in the mammæ, and apparently affecting the glandular structure rather than the adipose or cellular tissue; and Dr. Rownel has reported a case of cancer of the breast from which flowed matter as black as ink. Breschet gives the case of an old woman that died at Salpêtrière of ulcerated melanosis of the groin; and many similar tumors, varying in size from a nut to a pullet's egg, could be traced along the groin. Melanic matter has also been found in the thyroid gland, in the ovaries, and in the uterus.

Many authors have spoken of melanoma of the *muscles* and *bones*. Dr. Halliday found it in the sternum and in the ribs, and also in the parietal and occipital bones, which were coloured black. In this case, the bones were more fragile than usual, but the periosteum presented no marks of disease. Lobstein met with it in the left femur, and found several melanotic tumors adherent to the *periosteum*.

Melanotic formations have been found in many different parts of the sub-cutaneous cellular tissue in the form of round masses of various sizes, and which have ultimately ulcerated. Alibert speaks of them as spherical in form, and of the size of a juniper berry, and when cut into resembling the parenchyma of a truffle; while Breschet and Jurine compare them to mulberries. A remarkable case of this kind was, a few years ago, in St. Bartholomew's Hospital, the melanic tumors covering nearly the whole back. These tumors, if removed, are said to be re-produced.

*Symptoms.*—The symptoms of melanoma have not been determined. In the lungs the deposit produces no sensible effect, except the tumors are large, and thus impede the functions of the different organs of the chest. In the liver, the organ is enlarged, and otherwise diseased, but neither pain nor other symptoms mark the disease. In the bones it occasions fragility; in the lymphatic glands and sub-cutaneous tissue, ulceration; but it does not appear, in any case, to be attended with pain except such as may result from the pressure of the tumors on the surrounding parts. When ulceration takes place the patient has died; but he would equally have died from the ulceration had no melanic matter been found; and this is all that can be fairly said to be known respecting the symptoms of melanosis.

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*Diagnosis.*—The diagnostic symptoms between melanoma and many other tumors are not determined; when, however, it is superficial, the colour plainly distinguishes it.

Dr. J. C. Gregory examined a patient that died in the Infirmary at Edinburgh, who had been employed for the last 10 years of his life in the coal-mines at Dalkeith, inhaling coal-dust at every breath. In this case both lungs were of one uniform carbonaceous colour, which pervaded every part of their substance. The right lung was broken down in its upper and middle lobes into irregular cavities, and the walls of these cavities were black, and contained a considerable portion of a black fluid like ink. Portions of this lung were hepatized, and the rest of it, as well as the right lung, was infiltrated with a black serum. Dr. Christison analyzed the black serum (No. 109, *Edin. Med. and Surg. Journal*), and found its products similar to those arising from the distillation of coal. This case is curious, whether it be considered as an original or as a simulated disease.

*Prognosis.*—Death is supposed to follow melanosis of the liver, and ulceration of the cutaneous or other tissue or organ.

*Treatment.*—No successful mode of treating this disorder is known.

### Class III.—Of Morbid Poisons, and of the Diseases caused by them.—*Introduction.*

Morbid poisons are a class of substances secreted either by the patient's person, as that of typhus or of scarlet fever, or else generated by other sources, known or unknown, as that of cholera, or of intermittent fever. These poisons contaminate the healthy recipient, either in consequence of their miasmata being diffused through the atmosphere, or else by their being brought into still more direct contact with his person in his communication with the sick. The diseases they respectively engender are of a specific character, as measles, hooping-cough, or small-pox.

The diseases arising from these causes are numerous, and frequently of the most formidable description, and in the year 1839 they occasioned a mortality of 65,343, or nearly one-fifth of the whole number of deaths in England and Wales. The majority of them assume, on many occasions, an epidemic character; and history affords the most awful instances of their ravages. It is remarkable also, that many of these diseases, as the measles, hooping-cough, and small-pox, appear to have been of late formation, so that a date can be assigned to their first eruption. The cholera, also, which we have lately seen traversing Asia, Europe, America, and the northern shores of Africa, seems of this class, and is probably not of any considerable antiquity even in India, while in Europe and in America it appears to have been entirely unknown till its late appalling visitation, devastating the largest cities, and spreading over the fairest portions of the earth. Diseases consequently depending on this class of substances are most important, and merit on the part of the medical philosopher the gravest attention, both on account of their peculiar laws and complexity of phenomena, but also of their extreme intractableness and great fatality. The student can hardly be expected to understand this difficult subject, without some reference to the laws of poisons generally.

Poisons, of whatever nature, and especially medicinal substances, which are poisons when improperly applied, are subjected to certain general laws,—the most important of which are, first, that they have all certain definite and specific actions; secondly, that they all lie latent in the system a certain but varying period of time before those actions are set up; and lastly, that the phenomena resulting from their action vary in some degree, according to the dose, and to the predisposition of the patient. These laws are common to all poisons, but there are also many others which are peculiar to individual poisons or classes of poisons, and it may be necessary to notice a few of them.

The *first* law, or that of the definite and specific actions of poisons, cannot be doubted; for if it be supposed that agents acting on the human body do not produce their effects according to certain definite laws, we can neither determine the seat or course of any disease, nor direct nor judge of the operation of remedies. The definite action of causes is the basis of human knowledge, and must be equally true in medicine as in every other science. No physician, for instance, has seen castor oil produce tetanus, or colchicum intoxicate the brain, or opium inflame the spleen; he perfectly well knows that the first of these substances acts on the intestines, the second on the ligaments, and the third on the nervous system generally. The action of poisons, therefore, is not accidental, but determined by certain definite laws.

The action of poisons, though definite, is variously limited. Some poisons, for instance, act on one membrane, or on one organ, or on one system of organs; while other poisons extend their action over two or more membranes, or organs, or system of organs, or even over the whole animal frame. We have examples in aloes and jalap, of substances that act upon one membrane only, or on the mucous membrane of the alimentary canal. In digitalis we have an instance of a medicine that principally acts on one organ or the heart, greatly reducing or even stopping its action; while strychnine is an example of a medicine acting on one system of organs, or on the parts supplied by the spinal cord, producing powerful and sometimes fatal tetanic action of every voluntary muscle in the body.

It is seldom, however, that the action of poisons is limited to one membrane, or organ, or system of organs. The greater number of these noxious agents more usually act on two or more membranes, or organs, or systems of organs. Elaterium, for instance, acts on the mucous membrane of the intestinal canal and on the kidneys. Tobacco nauseates the stomach, intoxicates the brain, and affects the action of the heart. Antimony has an equally extensive range; it induces cutaneous perspiration, acts cathartically and emetically, and in large doses appears to cause gangrene of the lungs. Alcohol and opium are examples of substances acting still more generally, affecting not only the action or secretion of every organ or tissue of the body, but even in some instances altering their structure. Thus, alcohol has been shown to cause structural disease of the liver, of the stomach, and of the coats of the arteries, while opium tends to produce apoplexy and structural disorganization of the brain and its membranes. From the circumstance of these two substances acting not only generally but locally on a given number of tissues, they resemble in their effects those of many morbid poisons, as that of typhus fever, of scarlet fever, or of the small pox.

The *second* important law of poisons is, that they lie

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latent in the system a period of time which varies in different individuals, before they set up their specific actions. Rhubarb, for instance, produces no immediate result, but lies dormant in the system six or eight hours before its action is sensible on the bowels; opium, in the usual dose, is generally thirty minutes before it subdues the brain to its influence. The convulsions from strychnine do not follow till twenty minutes after its exhibition, and perhaps every substance, except hydrocyanic acid, has a greater or less sensible period of latency.

When a medicine, however, acts on more parts than one, a considerable space of time may elapse after it has affected one organ before it affects another: thus digitalis frequently occasions emesis before it acts on the heart, and the action of mercury on the bowels is frequently sensible for many weeks before the gums and salivary glands are affected. The doctrine of the latency of poisons is indeed so generally admitted, that their actual period has been a point on which the condemnation or acquittal of a prisoner tried for murder has turned in our courts of justice, when corrosive sublimate or hydrocyanic acid has been supposed to have been exhibited.

The *third* great law of poisons is, that being once roused into action, their effects are modified by the dose, the temperament, or the present state of the constitution of the recipient. The effect of dose in modifying the pathological phenomena of disease may be exemplified in the actions of oxalic acid and of arsenic. The specific action of oxalic acid is to inflame the mucous membrane of the stomach; but to ensure this effect the dose must be limited so that this poison may lie in the system many hours. On the contrary, if the dose be excessive and rapidly absorbed, the poison so disorders all the functions of the three great nervous centres that life is destroyed in a few minutes, and not a trace of disease is to found in any part of the body. Arsenic likewise is a poison which inflames and ulcerates the mucous membrane of the alimentary canal, but it requires some hours to set up its specific actions, for when the dose is large it in like manner destroys by general irritation, and not a trace of morbid change of structure is to be found after death. It follows, from this law, that the larger the dose or the greater the intensity of the poison, the more rapid its action and the less the probability of finding any trace of specific disease.

In studying the effects of dose on the constitution, we find some poisons are absorbed and are *cumulative*, while others are not absorbed into the system, or else are so rapidly removed that no cumulative effect is produced. Thus, in persons predisposed to the effects of digitalis, a dose so small as to produce no sensible effect whatever, will, if frequently repeated, at last destroy the heart's action. In cases, likewise, in which it is desirable to produce vomiting at the least expense to the constitution, the means employed are cumulative, or a repetition of small doses of ipecacuanha, or other emetic substance. This cumulative property of poisons, however, is by no means universal. There is no instance of jalap or of castor oil proving cumulative, and if a frequent repetition of them produces an increased effect, it is, perhaps, in consequence of the nervous papillæ with which they are brought in contact being more easily irritated by each application, and hence they induce a more violent result.

*Temperament* is also a circumstance which greatly influences the action of poisons. There are a few persons altogether insensible to the action of mercury, so that no quantity will affect their gums, or increase the secretion of the salivary glands. There are others, in like manner, the action of whose heart no quantity of digitalis will control. On the contrary, there are some constitutions so morbidly susceptible of these remedies, that it is scarcely possible to exhibit even a fractional dose without giving rise to their specific effects.



Besides natural temperament, *habit*, which may be termed an artificial temperament, has a powerful influence in reconciling us to particular classes of poisons, and of making them even sources of enjoyment. Thus tobacco, alcohol, opium, are all substances which in the first instance are to many persons productive of great discomfort, but by frequent repetition they cease to have any unpleasant effects, and their stimulus at length becomes a necessary indulgence. Still there are many poisons to which no repetition can habituate us, as arsenic, corrosive sublimate, or the preparations of copper. On the contrary, each repetition only the more debilitates the constitution, and renders it more susceptible of the action of the poison.

The present state of the constitution has also a powerful influence on the action of poisons; and it would seem proved, with some exceptions, that these agents act with an intensity proportioned to the debilitated state of the patient. There is indeed no duty more imperative on the physician than that of adjusting the dose to the strength of the patient, and nothing is more common than to forbear administering a medicine because the patient's strength will not admit of it. As a general principle, therefore, medicines may be said to act with a power proportionate to the debility of the patient.

Still there are states of disease which render the constitution of the patient, though greatly debilitated, insusceptible to the action of even powerful remedies. Thus, in typhus fever, the patient will often bear a considerable quantity of vinous stimuli without being affected by it. In tetanus, or hydrophobia, no quantity of opium will tranquillize the symptoms or procure sleep. Fallopius mentions a singular instance of the constitution being armed against the action of a poison. He states, that in his day a criminal was given up to himself and other anatomists to be put to death in any manner they might think proper. To this man, therefore, they exhibited two drachms of opium, but he labouring under a quartan ague, and the fit just coming on, the "opium was hindered of its effect." The man, therefore, having survived this dose, begged that he might take a similar quantity, earnestly entreating, if he escaped, he might be pardoned. The same dose was exhibited, but it was in the interval, and the man now died.

The experiments of Majendie may be referred to as affording many curious proofs of the state of the constitution in accelerating or retarding the actions of poisons. That physiologist has shown, if a poison be introduced into the system of such potency as usually to destroy life in two minutes, on bleeding the animal the same result will follow in half a minute, or in one-fourth of the time; and this experiment has often been repeated. Majendie has also brought to light the curious fact, if, after having poisoned the animal, and even after the poison has begun to act, we inject an aqueous fluid into its veins in such quantity as to cause an artificial plethora, that as long as this artificial plethora can



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be maintained the action of the poison is superseded. No sooner, however, does the plethora cease, from the general effusion of water which follows into every cavity of the body, than the poison acts in the usual time, and even perhaps with more than its accustomed severity.

Mr. Hunter thought that no two poisons could *coexist* in the same system together, or that, co-existing, they could not set up their specific actions at the same time. This hypothesis, however, is unquestionably erroneous; for we constantly see opium and digitalis, jalap and mercury, as well as many other combinations of medicines, producing their respective effects in the same system, and at the same time, by accelerating or retarding each other's actions. There is no truth better established in medicine, than that a combination of salts and senna produces a much more efficient and pleasant action than the exhibition of either remedy separately; and opium is an agent possessing a modifying or controlling power over every organ or tissue, without which it would be impossible, on many occasions, to reconcile the system to the introduction of many necessary and essential remedies. Poisons, therefore, are capable of co-existing together, and of so influencing the system that they reciprocally accelerate or retard each other's actions.

The general laws observable in the actions of medicinal substances are for the most part precisely similar to those which govern morbid poisons, or only differ in a few minor points; for these latter poisons have their specific actions and their periods of latency, while their phenomena equally vary according to the dose, or else the state of the constitution, or of the predisposition of the patient.

The specific actions of morbid poisons are distinctly proved by the fact, that we are enabled to determine, within certain limits, the course, symptoms, and pathological phenomena which result from the presence of any given morbid poison. No man, for instance, can confound the phenomena of small-pox with those of intermittent fever, or those of intermittent fever with syphilis, or those of syphilis with cholera; each of these poisons has its separate and peculiar laws, and consequently its actions are definite and specific.

The actions of morbid poisons also, like those of medicinal substances, are variously limited, some affecting only one membrane or organ, or system of organs, while others involve two or more membranes or organs, or systems of organs. Thus, tinea capitis is an example of a poison acting on one tissue of the body, and even then partially, namely, on the cutaneous tissue of the head. The waters of Switzerland contain a poison whose action is limited entirely to the thyroid gland. The contagion of hooping-cough and the virus of hydrophobia affect all the organs supplied by the eighth pair, or pneumogastric system. Instances of morbid poisons acting on two membranes or organs, or system of organs, are still more common, and form the great body of this class of disease. The poison of measles, for instance, acts no less on the mucous membrane of the eyes, nose, fauces, and perhaps on the mucous membranes generally, than on the skin. That of scarlatina acts not only on the mucous membrane of the fauces, and on the skin, but also on the serous membranes of the joints and of the abdomen. The paludal poison has a still more extensive range, hardly any organ or tissue of the body being exempt from its destructive ravages.

Morbid poisons also, like other poisons, have their period of latency; and, generally speaking, a much longer time elapses before their specific actions come into operation than takes place with medicinal substances. The virus of the natural small-pox lies dormant from sixteen to twenty days before it produces any constitutional disturbance; and a still further period elapses, of three or four days, before the specific eruption appears on the skin. The poison of scarlatina lies latent from seven to ten days after exposure to the contagion; that of the measles from ten to fourteen; while the poison of paludal fever has been known to lie dormant for a twelvemonth, and that of hydrophobia for a still longer time. These are examples of periods of latency far beyond anything that has been observed in the action of medicinal substances.

When morbid poisons act on more tissues or organs than one their actions are sometimes simultaneous, but more commonly they are consecutive, and frequently long intervals of time elapse between each successive attack. Thus, the poison of typhus fever may attack the lungs, the membranes of the brain, and the mucous membrane of the alimentary canal, and all these may be attacked contemporaneously; but it is more common that their attacks take place consecutively, or first on the alimentary canal, then on the brain, and lastly on the lungs, several days elapsing between each successive attack. In syphilis the poison acts on the part to which it is first applied—as the skin, throat, bones, and ligaments; and cases have been met with in which the throat, the skin, and the bones have been affected at the same time with the primary sore. It is more common, however, for them to occur *seriatim* and at very remote periods from the primary affection, so that many years frequently elapse before the poison has exhausted itself. In scarlatina also the peritoneum is not affected till many days after the eruption of the skin and the ulceration of the throat have altogether disappeared.

It occasionally happens that morbid poisons which usually act on a plurality of membranes, exhaust themselves on one or more without affecting the whole series. In the disease termed scarlatina simplex the poison sometimes exhausts itself entirely on the cutis without affecting either the mucous or serous membranes of the body. The rubeola sine catarrho is a similar example of the poison exhausting itself on the same tissue, the skin. In intermittent fever, when the dose of the poison is limited, and the disease properly treated, it is seldom that any organ or tissue is involved; yet, left to run its course, scarcely any organ or tissue would escape destruction.

Sometimes, when the morbid poison acts on many membranes, the usual order of attack is inverted. It is the general law of syphilis, that the bones are the last in the order of the secondary symptoms that suffer, but sometimes they are the first to be affected. In scarlet fever the affection of the skin may precede that of the throat, or the reverse may take place; and, in fever, the affection of the head may precede that of the intestines, though the latter is the most common.

It has been seen that the period of latency of medicinal substances being passed, and their actions set up, that their effects varied in a considerable degree, according to the dose, temperament, or present state of the constitution of the patient. With respect to the dose of a morbid poison, we rarely possess any direct measure of the strength of its miasmata. The paludal poi-

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son, however, of tropical climates, unquestionably greatly exceeds in intensity that of more temperate climates, and its effects are proportionally marked. Thus, in the West Indies, we have the yellow fever, with hardly a trace of organic disease after death; while, in Holland, we have a fever of less severity, but followed by enlarged livers or spleens, or else by dropsy; while, in this country, the fever is comparatively mild, and, if properly treated, for the most part terminates without any visceral affection. With respect to the influence of temperament in modifying disease, the small-pox offers very striking instances; for different persons inoculated or poisoned from the same source have suffered in every varying degree from this formidable malady, or from the horn, the distinct, the confluent, and the bloody small-pox; while, in the worst cases, the child has died in the primary fever, and before the specific action on the skin has been induced. It may, therefore, be laid down as a general law, that the more intense the dose of the morbid poison the more severe the form of disease; and also that fewer traces of organic alteration will be found after death than when the poison, or the disorder it produces, has been of a milder character. Thus, enlarged livers, disorganized spleens, and dropsy marked every case that died of the Walcheren fever, while in the West India and African fevers, though resulting from the same poison, scarcely a trace of disease is to be found.

The present state of the constitution also influences the event. Thus, persons of a good constitution, but ignorant of their danger, are often seen to pass through a mild form of typhus fever, while the nurses and others contaminated at the same source, but more alive to their critical state, have sunk without a struggle. As a general principle, therefore, it may be stated, that morbid poisons act with an intensity proportioned to the enfeebled or depressed state of the constitution; but this law is not universal. The hardy mountaineer is a surer victim, whether he visits the low countries of the tropics or the marshes of a more temperate climate, than the feebler native of those countries. The immunity the latter enjoys is probably owing to his habit of living in the noxious atmosphere; for let him remove to a more healthy climate, and then return to those regions of pestilence, and he will be found as susceptible of the poison as the hardiest stranger.

Another law of morbid poisons is, that two may *coexist* in the same system; thus, scald-head and fever, measles and scarlatina, have often been seen at the same time in the same person. In this case the respective diseases sometimes appear simultaneously, and each runs its course unaffected by the presence of the other; but the more usual law of febrile poisons perhaps is, that when two co-exist, the one lies latent while the other runs its course, or they interrupt each other's progress, the active one becoming latent while the latent one becomes active, and occasionally they modify each other's actions. A case of intermittent fever was admitted into St. Thomas's Hospital which was not controlled in the usual time by medicine; suddenly, however, it subsided, and the small-pox appeared. The small-pox having run its course, and the patient being recovered from that disorder, the intermittent fever returned, and now readily yielded to quinine. A child, having been exposed to the infection of the small-pox, was vaccinated; in a few days, however, the small-pox appeared, and ran a very mild and modified course. When the small-pox had entirely subsided some action was seen in the punctured part of the vaccinated arm, and the cow-pox vesicle formed, but not till three or four weeks after the time it usually appears, and then exceedingly small.

The principal points in which the laws of morbid poisons agree with those of poisons generally having been stated, it will now be necessary to state those circumstances in which they principally differ. Many medicinal poisons have the property of accumulating in the system, and acting with an intensity proportioned, not to the last dose, but to the aggregate of the whole quantity that has been administered. Thus the last few minims of digitalis may stop the action of the heart, or the last few grains of mercury salivate the patient. There is, however, no well-authenticated fact which can be arranged under this law in the whole circle of morbid poisons. A given quantity of a morbid poison is perhaps necessary to produce a given disease, but below that point the miasmata perhaps circulate without injurious effect. The actual quantity, according to the experiments of Dr. Fordyce, is perhaps extremely small; for that physician, in hopes of mitigating the small-pox, inoculated with virus greatly diluted. The disease was not always produced, but, when produced, it assumed every form, character, and degree of severity, according to the temperament or constitution of the patient.

Another peculiar law of morbid poisons, and one wholly unknown to medicinal substances, is the faculty which the human body possesses of generating to an immense extent a poison of the same nature as that by which the disease was originally produced. A quantity of small-pox matter not so big as a pin's head will produce many thousand pustules, each containing fifty times as much pestilent matter as was originally inserted; and moreover, the blood and all the secretions of the body are supposed to be also equally infected with the matter of the pustules. The miasmata secreted by one child labouring under hooping-cough are sufficient to infect a whole city.

Perhaps there is a still more remarkable law of morbid poisons, and unknown to those of a different class, which is, that many of them possess the extraordinary property of exhausting the constitution of all susceptibility to a second action of the same poison. This is the case with scarlatina, measles, the small-pox, the hooping-cough, and indeed with a considerable class of disease. Still it would seem that a temporary protective influence was imparted by most morbid poisons, for it is certain that few persons suffer a second attack of the same epidemic disease; and, consequently, it follows that the previous action of the poison must for a time impair the susceptibility of the constitution to its attacks. This beneficent law is of great importance in social life; it enables those that have recovered to attend on those that are sick, and allows a mother fearlessly to nurse her child in a dangerous and contagious distemper she has herself passed through.

It only remains to mention one other law, which is but little shared by poisons of the vegetable or mineral kingdoms. It is well known that the actions of vegetable or mineral poisons are not influenced by the climate in which they are administered. Climate, however, has the property of greatly modifying the intensity of morbid poisons. The severe forms of typhus so common in the north latitudes are hardly known in more southern latitudes, and the cholera has been infinitely more fatal



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in Europe and in America than in the country which gave it origin; but besides influencing the intensity of the disease, climate or season, or both, greatly modifying the specific nature of morbid poisons. In one season, for instance, typhus fever will attack only the glandular structure of the intestinal canal; in another only the mucous tissue of the same part, the glands or follicles being healthy; while, in another season, no disease whatever of the intestinal canal can be traced. Again, in one paludal district the liver will be inflamed and the spleen healthy, and in another the liver will be unaffected but the spleen disorganized. In both cases the genuine character of the disease remains the same, but its specific character varies. It will have been seen that this variety of pathological phenomena is also caused by peculiarity of idiosyncrasy, and that nothing can be more different than the distinct, the confluent, and the horn small-pox from each other; and yet all these different varieties may exist in different persons inoculated with the same poison. The character of the vaccine pustule is equally various; so that that which ensures exemption from the small-pox has not yet been determined; neither have pathologists determined the primary forms of syphilitic ulcers. It is important, therefore, to remember, in the study of morbid poisons, that absolute uniformity of pathological phenomena is not to be expected in different persons and in different seasons. There is a limit, however, within which their variations oscillate, and within which nature has bounded her deviations.

The laws of poisons are more important than their *modus operandi*; but this part of the subject has been deeply investigated by modern physiologists, and deserves some consideration. The great and striking alterations which often take place in the blood, led from a very remote period to the doctrine of humoralism, or that a morbid state of the fluids was the great and primary cause of disease. On the contrary, when anatomy began to be cultivated, and nerves traced into every organ and tissue, it was supposed that disordered actions of these prime agents of motion, and of the great phenomena of animal life, were the great causes of disease, the morbid state of the fluids being secondary. Fontana determined to prove this latter theory, and found, to his surprise, on laying bare the sciatic nerve in a great number of rabbits, that neither the venom of the viper nor the poison of the ticunas, nor hydrocyanic acid, when applied to it, produced the phenomena of poisoning, and that no other consequence resulted beyond what would have been produced by a similar mechanical injury.

Fontana having shown that the phenomena of poisoning do not result from the application of the deleterious agent to the trunk of the nerve or to the *solids*, determined to ascertain whether they followed after absorption, and consequently contamination of the *fluids*. He therefore injected the venom of the viper, hydrocyanic acid, or other poisonous substances directly into the veins of different animals; and he found that, although the nerves of a part may be steeped in these poisons with impunity, yet no sooner did the substance enter the veins, than the animal, after uttering a few horrible shrieks, struggled and almost instantly died, and thus demonstrated a morbid state of the fluids as well as the existence of a tissue of extreme sensibility, and with which the poison being brought into contact, accounted for the death of the animal. Fontana pursued this subject one step further, and showed if poisons acted by absorption, that this absorption was in many instances extremely rapid. He submitted a number of pigeons to be bitten in the leg by the viper, and chopped the wounded limb off at different intervals after the introduction of the venom, and found, as the result of an extensive series of experiments on several dozens of pigeons, that none recovered when the poisoned leg was removed at a later period than 25 seconds, though the phenomena of poisoning did not occur till several minutes later.

The experiments of Fontana had shown, supposing a poison to be introduced into the veins, that all the phenomena of poisoning were accounted for; but still it might be said that the fact of absorption was something wanting of strict demonstration; and for the further prosecution of this subject we are indebted to Segalas, who showed, if the arteries and veins of the mensentery of a dog be tied, that a quick acting poison would lie in harmless contact with the corresponding portion of the intestine for many hours; but no sooner were these ligatures removed than poisoning took place in a few minutes. Majendie even has carried this proof of the veins absorbing still further, for he amputated the leg of a dog, having first introduced a portion of quill into the femoral artery and vein, in such a manner that, on dividing these vessels, the leg hung connected with the trunk solely by means of the quill, all continuity by means of the solids being cut off. The poison was now introduced into the paw, and in four minutes the animal was under its influence.

By these experiments, it is apprehended that Fontana, Segalas, and Majendie have completely demonstrated the absorption of poisons by the veins, and consequently of their circulating with the blood; and that no doubt may remain on the subject, modern chemistry has demonstrated the actual presence of many medicinal substances either in the blood itself, or else in the secretions from it. Thus after a treatment by soda, large quantities of uncombined alkali have been found in the serum. Alcohol has been obtained by distillation from the blood; while iodine, rhubarb, the nitrate of potash, and a large number of other substances taken into the stomach, have been found in the urine. It follows, then, that poisons are absorbed and mingled with the blood, and are conveyed directly to the parts on which they act, passing with impunity over others for which they have no affinity.

The fact of morbid poisons in like manner being absorbed, and mingling with the blood, has been shown by many continental writers; but perhaps the experiment made by Professor Coleman is the most satisfactory. "I have produced the disease (the glanders) by first removing the healthy blood from an ass, until the animal was nearly exhausted, and then transfusing from a glandered horse blood from the carotid artery into the jugular vein. The glanders in the ass was rapid in its progress, violent in degree, and from this animal I afterwards produced both glanders and farcy." Both scarlatina and measles have also been produced by inoculation from the blood of patients labouring under those diseases.

The circumstance of the presence of a poison in the blood is supposed by Andral to produce, besides its toxicological states, certain alterations in its physical condition. Thus he conceives a specific cause has a tendency to destroy or reduce the quantity of fibrine in the

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blood, which he has found in some instances to be only one part in a thousand. Hence he adds, whatever may be the nature of the pyrexia, the blood, whether it be taken from a vein or collected from the heart and arteries after death, always exhibits the following characters—namely, that the serum and clot are incompletely separated the one from the other, so that the clot is consequently large, and often appears to fill almost entirely the bleeding-basin. Its edges also are never raised, and its consistence is inconsiderable, so that it is easily torn, broken down, and reduced to a state of diffluence, and in this state it becomes grumous, and discolours the serum. It is also remarkable for the absence of all buff, which is rarely met with in typhus, in measles, in scarlatina, or in small-pox, unless there has been some inflammatory complication; and even when it does exist, as in confluent small-pox, with large collections of pus, the buff is soft and gelatinous, and, by expression of the serum, is easily reduced to a thin pellicle. This defect of fibrine he conceives to be the cause of the great tendency to hæmorrhage, and to that stasis or congestion so remarkable in typhus, scarlatina, and other diseases dependent on morbid poisons.

The facts and arguments which have been adduced, have, it is apprehended, distinctly proved that morbid poisons act in all instances not capriciously, but according to certain definite and specific laws, modified by the influence of climate, temperament, or the magnitude of the dose; also, that they mingle with the blood, with which they continue in latent combination a certain but varying period of time; and likewise that many of them are capable of co-existing together in the same system. Two other remarkable laws result from the study of morbid poisons,—or that these singular agents are not acted upon by medicinal substances as long as they continue latent: and again, that when they act on more tissues than one, the remedy which is an antidote to its action on one is often absolutely powerless when it affects another tissue; so that many different remedies are frequently necessary to combat the varying phenomena of the same disease. A knowledge of these laws is necessary for understanding this class of disease, and it is hoped that by their application many of the difficulties which have hitherto obscured the doctrines of fever, of syphilis, of hydrophobia, and of many other diseases incident to the class of morbid poisons, may be removed, and that this portion of medical science may be placed on a surer foundation, if not on a permanent basis.

### Of the Typhoid Poison.

Typhus fever is the only continued fever of this country; it runs an indefinite course, has no intermissions, is of great fatality, and is both infectious and contagious. The number of persons reported to have died of this disease in England and Wales, in the year 1839, was 15,666.

It is uncertain whether the ancients were acquainted with this fever,—at least none of their descriptions correspond to it. The first authentic accounts of it are to be found in the early British chronicles, and they describe it as spreading in our courts of justice, and giving rise to what have been termed "the black assizes." The last black assizes happened at the sessions of the Old Bailey in 1756, when the lord mayor, two of the judges, and several eminent and other persons died infected, as was supposed, by the prisoners. This fever has had many popular appellations—as the jail fever, hospital fever, ship fever, putrid fever, brain fever, bilious fever. We are indebted, however, to Pringle and to Fordyce for having shown that these supposed different fevers are identically the same, and have no such essential differences as constitute them distinct genera. The phenomena of typhus indeed vary in some degree in different years, and in different persons in the same year, but not to a greater degree than those of small-pox or of scarlet fever. While the British physicians were employed in generalizing this fever, and in determining many of its laws, the French physicians, and especially Serres, and Petit, and Louis have the great merit of having perfected its pathology.

*Remote Cause.*—Typhus fever prevails not only in Great Britain but likewise over a great part of the north of Europe, and also of North America. Indeed its range may be said to be limited to the space between the 60° and 40° of north latitude, for it is little known to the south of the Mediterranean and towards the equator. The poison appears, therefore, to have a local origin, but the mode of its generation has hitherto eluded the penetrating search of all those who have hitherto attempted the investigation of this difficult branch of medicine.

The decomposition of vegetable matters is found to give rise to paludal, or to the class of intermittent fevers, and consequently the causes of typhus fever have been sought for in the decomposition of animal matter. A large body of facts, however, prove that this hypothesis cannot be true; for Dr. Bancroft has shown that the classes of persons most employed about animal matters, as butchers, curriers, sugar-bakers, knackers, and others, are remarkably exempt from fevers. It has been next thought that the decomposition of the human body generated this virulent poison; but many thousand bodies have been dug up, with a view of levelling churchyards, both in this country and in France; they have been re-coffined and re-interred, and this at all seasons of the year, but without the persons employed being in any degree affected with fever. The experience also afforded in our anatomical theatres shows that dead animal matter does not cause fever; Dessault used to affirm, from the general exemption of his pupils, that the old proverb "morte la bête mort le venin" was proved; and Lallemand and Dubois adopted the same maxim. Ribes, whose class amounted from 120 to 160 pupils annually; and Serres, after witnessing the effects of dissection on an aggregate number of 9600 pupils, both assert they never remarked any disease existing among their pupils which could be attributed to the emanations incident to the dissecting room. Dupuytren, Dumeril, Jadelot, Breschet, Andral, and Parent du Châtelet, all bear similar testimony, and some even assert the greater exemption of the pupils of the dissecting-room to be remarkable compared with those frequenting the wards of the hospitals. The hypothesis, therefore, of the poison of typhus fever emanating from the putrefaction of dead animal matter does not at present appear to be satisfactorily supported, although the depressing effects of miasmata thus generated probably greatly predispose to the disease.

The impossibility of assigning any definite origin to the typhoid poison has led to the inference that it may have a telluric source, and be evolved according to laws not yet understood. The grounds for this opinion are, that although typhus fever is endemic and sporadic at

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every season of the year, yet that it is occasionally greatly epidemic, and at irregular periods, varying it is supposed from four to sixteen years. When epidemic, it continues to prevail to a great extent for two or three years, and has its commencement, its point of culmination, and its period of decline in each year. Another argument for this hypothesis is, that it appears little influenced by season, prevailing to nearly an equal extent in winter, spring, summer, and autumn, so that the poison must be extricated under conditions little influenced by temperature. At all times, also, it follows the law of most poisons supposed to emanate from the earth, or that it most affects low countries, the banks of rivers and canals, although in epidemic seasons it prevails equally on the mountain as on the plain. Its greater prevalence, particularly in crowded districts of cities, in addition to their being generally low and ill drained, may be accounted for by the fact of the contagious nature of the disease. Supposing this poison then to have a telluric origin, it is probable, from the disease being unknown in tropical climates, that it must be volatilized, destroyed, or decomposed, at a not very high temperature. From its pathological phenomena, moreover, varying in different seasons, and in different epidemics, it is evident the poison undergoes certain modifications from some unknown combination of causes.

*Predisposing Causes.*—There are few diseases where the predisposing causes so greatly influence the reception of the poison as typhus; for although this surprising and appalling malady occasionally attacks the wealthy, yet it is admitted to be the disease of the *poor*, and not of the *rich*. Dr. Baillie stated, that in his extensive private practice he had scarcely met with an instance of typhus fever, and this in seasons when the *poor* were falling in large numbers. The physical condition, the many privations, and the mental sorrows of poverty are among the most powerful predisposing causes of typhus; and when, in addition to these, bad draining, defective ventilation, bad supplies of water, increased filth, and overcrowding are present, the mortality is often frightful. This statement cannot be better illustrated than by adding, that the average number of deaths in the gentry living at Bath, is 1 in 55, while in the *cellar* population of Liverpool the average age of death for the whole town is 17 to 18 years only. In every large city the great spread of fever is limited to its worst localities, as Whitechapel, the low districts along the banks of the Thames, the courts about Holborn, and the crowded population of St. Giles's. Famine enhances all these accidents; and though not the cause of fever, yet greatly prepares the system to receive the fatal germ of this pestilence. In Ireland, from the year 1721 to 1728, there was scarcely a case of fever; but after the latter year three bad harvests occurred in succession, and provisions rose to an extravagant price, and now fever broke out and continued to be epidemic till 1732. The year 1739 was also one of great scarcity, and fever again broke out and continued to prevail with such virulence, that in 1741, 80,000 persons are estimated to have died in Ireland from this cause alone. In the year 1800 there was a similar scarcity, and a similar prevalence of fever; and again in the year 1816, not only a year of famine, but of great commercial distress, fever again raged to a most distressing extent not only in this country but even in a great part of Europe. In the present year, 1843, fever is said to prevail in Glasgow to such a degree that the number of burials exceeds that of the most fatal years of cholera, the condition of the pauper being a penny a day allowed by the parish.

Armies on actual service are exposed for a time to almost all the severest privations of civil life, together with the addition of great fatigue; and the history of every campaign in Europe has shown that no sooner has the army entered into winter quarters, than with hardly an exception fever of a most destructive nature has broken out among the troops, spreading along their communications, and devastating long lines of country.

The extent indeed to which fevers prevail in armies cannot be better shown than by stating the report made to Napoleon after the termination of the campaign of 1807, by the peace of Tilsit, of the numbers of the troops admitted into hospital, by which it appears there were—

| | |
|---|---|
| Of Fevers | 210,000 |
| Killed and wounded | 100,000 |
| Venereal | 62,000 |
| Miscellaneous | 48,000* |

Again, in the campaign of Moscow, fever even more than the sword hung upon the traces of the retreating army, and thinned the ranks as fatally as the snows of Russia. Of this fever Kutusoff died, at his head-quarters at Bunzlau, after having delivered Russia in the extremity of its peril, and achieved the overthrow of the mightiest armament of which history has preserved a record. This fever spread its ravages for the next four years through every kingdom in Europe.

The influence of other predisposing causes is much less marked: sex does not appear to affect the liability, except perhaps from women being more exposed as attendants on the sick. Thus, in Glasgow in 1836, of 2260 cases 49·5 per cent. were males, and 50·15 per cent. females. In Edinburgh in 1819, of nearly 16,000 patients, 57 per cent. were females, and 43 per cent. males.

All ages are liable to typhus, but the extremes of life have a trifling exemption. Thus, Dr. Cowan found in the epidemic in 1836, that at Glasgow the proportion of deaths according to age was as follows:—

| Ages | 5 to 10 | 10 to 15 | 15 to 20 | 30 to 40 | 40 to 50 | 50 to 60 | 60 |
|---|---|---|---|---|---|---|---|
| Population | 25,707 | 21,211 | 20,745 | 26,419 | 18,014 | 11,640 | 10,220 |
| Fevers | 191 | 318 | 501 | 309 | 128 | 43 | 11 |
| | 1 in 134 | 1 in 66 | 1 in 41 | 1 in 85 | 1 in 140 | 1 in 270 | 1 in 920 |

* Alison's History, vol. vi., p. 308.

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Season has some but not great influence over this affection; for out of 51·944 cases of fever admitted into the different hospitals of Great Britain and Ireland, the total number in January was 2895, February 2825, March 3152, April 3374, May 3090, June 4365, July 4999, August 5621, September 5046, October 5624, November 5054, and in December 5359. The disease therefore appears to be more frequent in summer and autumn than in winter and in the spring, in the ratio of 3 to 5. The effects of a town life, compared with a country life, in predisposing to typhus, is not determined. In the years 1838 and 1839, the numbers per cent. of the population that died of typhus in the metropolis were ·219 and ·296; while in England and Wales the proportion for the same years was ·125, and ·101.

The poison, however fostered or generated, yet having once produced the disease, establishes a new source of infection in the patient's person, which now secretes a poison which is both contagious and infectious.

*Infectious.*—The proof of the infectious nature of the typhoid poison is, that in hospitals we often see patients labouring under other diseases, as soon as a case of fever comes into the ward, shortly afterwards fall ill of that fever, although they have not left their beds, or in any way approached the infected person; and this occurs when other persons in the same building, and in every respect similarly circumstanced, except living in the same ward with the fever patient, escape.

The distance to which the miasmata may extend around the patient's person so as to communicate the disease is not accurately determined. Experience, however, has shown that in a large well-ventilated ward a space of three feet around the patient's person so dilutes the poison that the disease rarely spreads. When, however, three, four, or more fever cases are collected in the same ward, nobody in that ward is safe, and patients the most remote from the diseased person will take the disease. It is under these circumstances that the students, nurses, and hospital attendants of every kind constantly fall from fever in large numbers.

*Contagious.*—The argument for the contagious nature of this disease is, that it has been observed that the gentlemen employed to bleed, and the nurses employed to exhibit enemata to the fever patients, have been the parties who have at all times been seized in the largest proportion with typhus, the danger increasing according to the degree of personal contact: the most striking proof, however, of its contagious nature is its spread by

*Fomites.*—The communication of the disease by fomites has been proved by the laundresses at the fever-houses, and who have no immediate intercourse with the patients, falling ill in unusual numbers. The persons also employed to take care of the clothes of the soldiers sent to the Hospital Salpêtrière, labouring under fever, in the disastrous campaign of 1814, fell ill of that disease. Another satisfactory proof of the contagious nature of fomites, is the endless succession of persons seized with fever in the lodging-houses for the poor throughout the country, caused by the miasmata, as is supposed, adhering to the walls and furniture of the room.

*Mode of Absorption.*—The typhoid poison, being diffusible through the atmosphere, must be introduced into the system by means of the mucous membranes, and being also contagious it seems probable it must be absorbed by the skin.

*Period of Latency.*—The typhoid poison, being absorbed into the system, infects the blood. This was proved by Mr. John Hunter, who injected into the veins of a bitch half-gone with pup a quantity of serum taken from a person ill of fever, and who soon after died. The animal turned instantaneously sick, vomited, and soon miscarried, but in two or three days recovered. Gendrin injected an ounce of blood drawn from a person labouring under fever, into the cellular membrane of the groin of a cat. The animal vomited, and died in seven hours. As these accidents would not have happened with healthy blood, it may be inferred that the poison infects the blood, and circulates with that fluid in a latent state, for a period which varies greatly in different individuals. Some persons have sickened immediately on entering the chamber of a person ill of fever, and others have vomited on examining the fæcal matter he has passed; but in general the period is much longer, and its extremes may be stated at from two days to two months—the more usual period being from two to three weeks.

*Co-exists.*—It is not unusual to witness the combination of typhus and syphilis; of typhus and erysipelas; of typhus and the itch, in the same person. Typhus, therefore, may co-exist with many other affections depending on morbid poisons.

*Pathology.*—The theory of this disease is, that the typhoid poison having been absorbed and mingled with the blood, lies latent a certain period, after which it primarily induces certain derangements of function of the great nervous centres, as the brain, the cord, and great sympathetic, and consequently of the organs they supply. These derangements constitute the phenomena of fever, and are—alterations of temperature—changes in the force and frequency of the pulse—disorder of the alimentary canal—headache, and other concomitant affections. In severe cases the fever thus established has destroyed the patient in a few days, without leaving a trace of inflammation or other organic disease in any part of the body. More generally, however, after the fever has lasted a given time, as a few hours, or a very few days, certain secondary actions or "*specific inflammations*" are set up in a limited number of the organs or tissues of the body,—as inflammation of some portion of the mucous membrane of the alimentary canal; 2ndly, inflammation of the brain, or its membranes; 3rdly, certain cutaneous eruptions; and lastly, inflammation of the bronchial membrane, or else of the substance of the lungs. The poison, however, does not necessarily run through all this series, but often exhausts itself on one or more of the above-mentioned tissues. Thus, in one year the lungs will be attacked in every case; in others, the membranes of the brain; and in others, the alimentary canal; while in other years such attacks will be rare, and the exception and not the rule of the disease. The order, also, in which the organic lesions are set up varies much in different years. Sometimes the membrane of the brain will be first affected—at others, the tissues of the alimentary canal; and at others, the substance or other part of the lungs. Such irregularities are common to all morbid poisons, and many years must elapse before the relative frequency and order of their occurrences can be determined, and this intricate problem of pathology unravelled.

The popular nature of this treatise and our very limited space will not allow us to enter very minutely into the pathology of fever; but when the typhoid poison

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produces inflammation of the mucous membrane of the alimentary canal, its seat may be either the web of the membrane, or its connecting cellular tissue, although commonly both are affected, or else its follicular structure.

The law which determines this election of the poison is not understood; but it is ascertained that in many years the follicles are the parts principally affected, while in others they are with few exceptions healthy. Thus, from 1813 to 1832, scarcely a case of fever was examined in which the follicles of the alimentary canal were not found ulcerated or otherwise greatly diseased. In 1832, however, when the cholera appeared, the follicular structure almost ceased to be affected, and the web of the mucous membrane was more generally inflamed; again, in the years 1837–8, though the follicles and web of the membrane were occasionally seen affected, yet for the most part not a vestige of the inflammation of any part of the mucous membrane of the alimentary canal was observed. When the inflammation attacks the web of the membrane, that inflammation may be either the diffuse, the serous, or the ulcerative; and in all these instances the colour of the inflamed part is of a deep venous red, almost approaching to blackness. When the follicular structure is inflamed it is liable to the serous, the adhesive, or the ulcerative inflammation. In the one case the gland is enlarged and transparent, in the other hard and granular, whilst in the last the ulcer may take a variety of forms. Indeed, the tendency of every inflammation of the alimentary canal is to ulcerate, and the number of ulcers is various, or sometimes only one; sometimes several, even to affecting every patch of Peyer's glands, while in the stomach they are sometimes so numerous that that organ appears to be riddled. It occasionally happens that some one of these ulcers burrows so deeply that it ruptures the peritoneum, and the patient dies of peritonitis. The parts of the alimentary canal usually attacked are the cæcum or ileo-cæcal valve, the inflammation extending upwards and downwards, often for several inches. In a few instances the colon or small intestines are the exclusive seat of the disease, and in still rarer instances the stomach; but it frequently happens that the inflammation is seated in two or more of these parts. Again, when the adherent surface of the mucous membrane of the alimentary canal is the seat of the disease, the inflammation is either the diffuse or suppurative. When the former, the connecting cellular tissue is rendered more easily lacerable than in health, and consequently considerable portions of the mucous membrane can readily be detached by the handle of the scalpel. In the latter case, a number of small abscesses form like so many pock, which at length rupture into the intestinal canal. In general, when the intestines are inflamed or ulcerated, the mesenteric glands corresponding to the diseased part are enlarged and evidently inflamed, but whether from sympathy or from a specific action of the poison is not determined.

The parts next to the intestinal canal, which are the most important as well as the most frequent seat of the action of the typhoid poison, are the brain and its membranes. Diseased function of the brain, as delirium, exists in five cases out of six in typhus; but delirium of the most marked character is often unattended with any trace of inflammation, either in the membrane or of the brain itself. Dr. Tweedie states, that he examined fifty-four cases that died with well marked symptoms of cerebral affection, yet in fourteen cases no trace of disease in the brain or its membranes could be found. When the brain is affected it is generally found to be abounding with more points of blood than usual; a state of parts supposed to be diffuse inflammation of that organ. Some small portions at its surface, also, are sometimes softened, or achromatously inflamed; but in other respects the brain is healthy. The membranes of the brain are much more frequently diseased than its substance, and are the more specific seat of the poison in fever; they are liable to all the degrees of inflammation to which they are at any time subjected, as the diffuse, the serous, the adhesive, and the purulent. The serous inflammation, however, is the most common, and the quantity of fluid effused varies from a drachm to an ounce or more, and this is generally mixed with points of lymph or pus.

The organs next in order of attack are the lungs; and the frequency with which they are attacked varies greatly in different seasons. Some seasons will pass with scarcely a single case of this tertiary action of the typhoid poison, while in other seasons every case of fever will show more or less affection of the lungs. The bronchial membrane and the substance of the lungs are the parts affected; but the former is most frequently attacked, and is the seat of the serous or of the purulent inflammation. When the substance of the lungs is inflamed, that structure is liable to the diffuse and serous inflammations, and also to the red and grey hepatization; but of these the serous inflammation is the most common, and it is not unfrequent to see flow from the lungs, as they are removed from the body after being cut into, a sero-sanguineous fluid, as abundantly as from a large sponge.

The cutaneous tissue is more constantly affected in typhus than the lungs, but its affections are of less moment. These affections also greatly vary in frequency in different seasons; for in some years they equal 70 per cent., while in other years their occurrence is only occasional and accidental. These affections are petechiæ and sudamina. The former consist of a number of small round spots, like flea-bites, of a dull roan colour, slightly salient, and from half a line to two lines in diameter. Their more common seat is the chest, the abdomen, and more rarely the thighs, arms, face, and back. This eruption does not appear on all parts it attacks simultaneously; neither does it appear to follow any given order of succession. It consists of many different crops, whose duration is not always the same; for in some cases they will disappear after two or three days, while in others they will last twelve or fifteen days. Chomel is of opinion that the same part may be affected by a succession of crops, each dying away at the end of three or four days.

The sudamina are small hemispherical vesicles, or transparent bladders, from a quarter of a line to a line in diameter, formed in the cutis, and so transparent that when we look at these little bladders obliquely their appearance is most brilliant. Regarded, however, in a direction perpendicular to their axis, they are so diminutive as frequently to escape observation. Still they are always sensible to the touch, and if pressed they rupture, and the finger is moistened by the fluid they contain. This fluid, perfectly transparent when the vesicle is first formed, Chomel affirms, becomes opaque after a few days, and no longer fills the vesicle, which shrivels, and at length desquamates. This eruption is often seen in the first instance on the sides of the neck—in the axillæ—in the

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Elementary Principles of Medicine.

groin, and in many cases it is limited to these spots. In other cases, however, it covers the whole trunk, and in others the whole body. This eruption appears later in the disease than the petechiæ, and most frequently about the middle or end of the second stage of the fever.

Ulceration of the nates and back sometimes takes place towards the end of this fever, but appears to result rather from the debility of the patient and his supine posture than from any specific action of the poison.

*Symptoms.*—The varying intensity of typhus fever has induced pathologists to divide this disease into typhus mitior and typhus gravior. This division is founded in nature; but it seems proper also to add a subdivision founded on the different affections of the cutaneous tissue, and the arrangement of its varieties will then be as follows:—

| | |
|---|---|
| Typhus mitior - - - - | Typhus gravior. |
| Typhus mitior petechialis - | Typhus gravior petechialis. |
| Typhus mitior sudaminalis | Typhus gravior sudaminalis. |

The structural lesions of other organs or tissues than the skin afford no data for a further generalization, because the lesions are so frequently similated by mere functional derangements, or else masked by local insensibility, that perpetual error would arise from the adoption of new species founded on them.

According to Chomel, out of one hundred and twelve cases of typhus fever, in seventy-three cases the invasion was sudden, while in thirty-nine it was preceded by headache, pains in the back, nausea or vomiting, constipation or diarrhœa, together with slight rigors followed by heat, and terminating either with or without sweats. When these symptoms exist, they usually last two or three days, some increasing and others disappearing, till at length those which are more particularly characteristic of typhus are established.

Typhus fever is compounded of primary fever, and of such symptoms as the organic lesions may give rise to. The phenomena of fever are supposed more particularly to consist in shivering, heat, sweating, and in an increased frequency of the pulse; but though these may be all present, yet each and all of them may be wanting. Rigors, for instance, are often absent; the temperature of the body may be lower than natural; the sweat is at all times accidental, and the pulse in a few cases is preternaturally slow. The phenomena of typhus fever, therefore, must be sought for in other than the group of symptoms that have been mentioned.

The most remarkable symptom of the typhoid poison is the extreme degree of prostration, both of the physical and intellectual powers of life, which it produces. This is so great that there are few patients who are not compelled to take to their beds on the first or second day of the attack; for they cannot take a step without staggering or falling, nor sit up unless supported; and even when in bed are hardly able to change their position, or assist themselves in any manner. The functions of the brain are equally depressed, and somnolence in a greater or less degree is almost universal; so that the patient is aroused with difficulty, and relapses on ceasing to be questioned. In this state their memory, though ordinarily correct, is slow; their minds, though not perverted, are incapable of all intellectual exertion, and they lie indifferent to all around them, and even to their own situation. The effects of the poison, of course, vary greatly in degree; but although delirium is often active in the first instance, yet the group of symptoms which has been described is by far the most common.

This depressed state of the powers of life has often proved fatal to the patient in the first few days; but these are exceptions, and more commonly the disease runs its course, and is divided into three stages, each stage being known by the state of the tongue, which is in the first stage white, in the second brown or black, and in the third, in the event of the patient's recovery, it again becomes white, and at length natural. These states of the tongue do not indicate any given organic or functional lesion, either of the brain or alimentary canal; for it is equally white, or covered with sordes, whether those parts be or be not inflamed. They consequently merely mark the degree in which the system labours under the action of the poison. These different stages, however, are generally accompanied by certain states of the vascular system. In the first stage, then, or as long as the tongue is white, the pulse is generally full and strong, and seldom exceeds 90 to 110; in the second or brown-tongue stage, the pulse is small, and is frequently increased to 120 or 130; and in the third stage, it either gradually returns to its natural standard, or else becomes almost countless—a mere vibration, and in this state the patient's case is generally hopeless. The duration of these stages is very various, and even some one or more of them may be wanting; but in a twenty-one days' fever each stage may last a week, but more frequently they are of unequal length, and the disease much longer.

The symptoms of typhus, it has been stated, are compounded of those of the general depression and of those which result from the accompanying functional lesions of the alimentary canal, the brain, the lungs, or of the skin.

With respect to the alimentary canal, *Diarrhœa* is the law in fever, and prevails in a great majority of cases. Most patients, for example, are purged from the very first day of the attack, in a greater or less degree; and many, unless it be checked by medicine, pass eight or ten stools, or more, in the twenty-four hours. The nature of the dejections is peculiar, and, in the great majority of cases, they are darker in colour than in health, and when the follicles are diseased contain large flakes of thickened mucus, which, floating about and deeply tinged with bile, appear like small portions of the variegated moss that grows on the tiles of houses. Frequently the stools are grumous, and, according to Louis, assume the character of coffee-grounds; while in a few cases blood is passed, and sometimes in amazing quantities, filling the chamber-vessel.

Another symptom is *meteorism*, or the effusion of air into the large intestine. This is present in a greater or less degree in one-half of the cases, and when considerable it always marks a grave affection, and one generally fatal. On the contrary, the abdominal muscles are in a few cases tense, and strongly contracted.

The above symptoms are present whether the alimentary canal be or be not inflamed; but when inflamed, as a general rule the patient experiences no pain, or only when strong pressure is made. The seat of the pain, whatever part of the alimentary canal be affected, is either immediately over the ilio-cæcal valve, or else over the epigastric region. In a very few instances the intestine ruptures, and the patient dies in great agony from peritonitis.

It is seldom, however, that the fever runs its course without greater complexity both of symptoms and of



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lesion; for the brain, or the membranes of the brain, or both, most commonly become either simultaneously or consecutively affected with the alimentary canal. In these cases the symptoms which arise from their condition will be added to those already described; but it has been stated they are often present when the function of these parts is merely disordered, as well as when they are inflamed.

Inflammation of the membranes of the brain may be divided into three stages, though some one of them is often wanting. The symptoms of the first stage are severe and constant pain in the head, occupying ordinarily the frontal region; the face, sometimes pale and sometimes red, being greatly expressive of the distress the patient suffers. The eye, haggard or brilliant, with its conjunctiva injected, is painfully sensible to the light, and is, therefore, generally closed. The least noise is insupportable, and the patient is troubled with noise in his ears. His temper also is altered, and his answers short and fretful. This stage, then, is that of increased excitement, but not as yet of delirium, and, supposing the membranes to be inflamed, denotes diffuse inflammation of those tissues. At the end of a period of time, varying from two to ten days, this stage terminates, and the second stage is ushered in by the patient becoming delirious. His delirium may assume every character, and be joyous or melancholy, furious or tranquil; and in some cases he wanders from subject to subject, while in others he incessantly recurs to the same theme, and even to the same few words. In others, though the cases are few, the disease assumes every character of insanity; and, if permitted, the patient confined in a strait waistcoat presents the extraordinary spectacle of being able, in typhus fever, to walk about the wards. The phenomena of this stage show that the inflammation of the membranes of the brain has extended to the substance of the brain itself. The last stage, or that of effusion, commences by the active delirium changing into a low muttering, by the patient no longer requiring restraint, by his muscles becoming spasmodically affected with slight twitchings, or subsultus tendinum, showing how rapidly the nervous power is exhausted, and how feebly supplied; also by the pupil of the eye becoming expanded or contracted; by the fæces being passed involuntarily; by the urine being retained; and by the rapid grouping of those other symptoms so happily described by Shakespeare, as the stone coldness of the feet creeping "upward and upward," "the babble of green fields," and the "fumbling of the bed-clothes," and which indicate approaching death. When the patient recovers, however, from this stage, the appetite improves, the pulse becomes fuller and steadier, the countenance more tranquil, the mind firmer, his sleep natural, till at last convalescence is fully established.

If, in the course of the disease, the poison falls on the lungs, the symptoms denoting inflammation of these organs will necessarily be added to those of the brain and of the alimentary canal, though these latter have generally much abated at the time of this occurrence. If the inflammation be confined to the mucous membrane, the symptoms are a short dry cough, with a mucous or purulent expectoration, and perhaps mixed with blood. Should the substance of the lungs be affected, crepitation, or a loud mucous rattle, is heard all over the chest, while the countenance becomes livid and swollen, and the breathing loud and laborious,—symptoms which sufficiently denote the nature of the lesion the lungs have sustained.

With respect to the cutaneous tissue, it is sometimes dry, but more commonly the patient is covered with perspiration, which gives no relief. It should be added, that on the eruption of petechiæ or of sudamina, the disorder appears to be neither aggravated or ameliorated. The sudamina, however, in general mark a milder fever than the petechiæ.

*Diagnosis.*—The nature of this fever cannot be determined during the few first days of the attack; for the fever which precedes the eruption of small-pox, of a common cold, and of many other disorders, in no respect differs from that of the first stage of typhus. If, however, the fever continues unabated at the end of four or five days, and with no eruption or other circumstance to account for it, there can be no doubt the disease in question is typhus.

*Prognosis.*—The prognosis to be formed of typhus varies greatly according to the circumstances in which the patient is placed, and to the severity of the type. Desgenettes says, of 25,000 men who reached Torgau after the disastrous campaign of 1813, 13,448 perished of typhus in four months. At Mayence, says M. Fauverge, of 60,000 troops, 25,000, or $\frac{5}{12}$ths, died of typhus. In France, it is estimated that from one in three to one in four and a half is the proportion of deaths to attacks. In this country, it is calculated that only one falls in six or seven of those attacked. In some years, however, when the fever is mild, the recoveries are much larger; while in years in which the type of the fever is low, the ratio is much smaller. Age has a great influence over recovery. Dr. Arthur Thomson affirms that the risk of life in fever is twice as great at 31 as at eleven years old; twice as great at 41 as at 21; and five times as great at 61 as at 11 years. The following table, however, from Mr. Watts's inquiry into the mortality from fever, in the great towns in Scotland, is a nearer approximation to the solution of this problem, or—

| There died per cent. of those attacked in the towns of | Under 10 Years of Age. | From 10 to 12. | Above 12. |
|---|---|---|---|
| Edinburgh . . | 12 per cent. | 29 | 70 |
| Glasgow . . | 12 ,, | 29 | 70 |
| Perth . . . | 15 ,, | 30 | 69 |
| Dundee . . | 19 ,, | 51 | 48 |

Women are supposed to have more chances of recovery than males.

*Treatment.*—As typhus depends on the system being impregnated with a poison for which no antidote is at present discovered, the fever, whatever be the mode of treatment adopted, uniformly runs its course, modified only by the treatment, the season, and by the temperament of the patient.

The antidote to the poison of typhus, if it exists in nature, being undiscovered, what is the best mode of treating this formidable disease? In typhus fever there is almost uniformly present in the first stage a full pulse, an increase perhaps of temperature, considerable headache, inflammation of one or more organs or tissues, and the blood when drawn in the first stage is occasionally buffed. Ought we, under these circumstances, to bleed? To this practice, however, the experience of Huxham, Pringle, Lind, Carmichael, Smyth, Fordyce, and even of the celebrated Mr. John Hunter, is decidedly opposed; for they affirm that, although in mild cases of fever some blood may be taken with impunity, still it rarely benefits the patient, while in severe cases its injurious effects are strongly marked. In modern times, Andral has bled in

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fever, but with so little success that out of 74 cases thus treated 35 died. Louis has also repeated this experiment; and he says that of 52 cases that died of fever, 39 were bled a greater or less oumber of times; and that the course of the disease was more rapid and fatal in proportion as the first bleeding was large and practised at the earliest period of the disease. He also adds, that the delirium was aggravated rather thao relieved, and that it caused no sensible alleviation of the abdominal affection—results certainly anything but favourable. Cruveilhier also states that typhus ought not to be treated after the manner of diseases essentially inflammatory. Such is the evidence against bleeding in fever, and demonstrating that operation to be the exception and not the rule of treatment in this formidable disorder—a deduction which is perfectly in accordance with all we know of morbid poisons—it being proved by repeated experiment that when ao animal is poisoned, the poison is more rapid in its course, and more fatal in its consequeoces, in proportion to the degree the animal has been bled.

We should therefore never forget, in the treatment of this disease, that it has a course to run; and secondly, that in most cases there is a series of local ioflammations to be set up, as in cases of scarlet fever, measles, or small-pox,—inflammations which no art can preveot, and which, when moderate, render the disease both milder and safer than when such inflammations are altogether wanting; and also, that the general as well as specific actions of the poison are, for the most part, greatly increased by large bleedings, or by severe and unnecessary depletion of any kind. The utmost, perhaps, that can be said for bleeding, is, that in mild cases it may sometimes be practised with impunity.

With respect to the few positive rules in the treatment of fever, experience has shown that they vary, in some degree, according to the nature of the affections of the alimeotary canal. When, for instance, the follicular structure of the intestines is inflamed or ulcerated, it seems proved hy a large number of cases that a local treatment by enemata composed of decoct. hordei lb. ſs. to lb. j. c. syr. papaveris, ℥ ſs. to ℥ j. is by far the most successful treatment. These exhibited oight and moroing remove all those causes which can irritate the inflamed part, and thus soothe and tranquillize the system generally. In addition to this, if the abdomen should become meteorized, a large linseed poultice should be applied over the abdomen and kept on for many hours. In this form of the disease no advantage appears to have beeo derived from the application of leeches or blisters to the abdomen or temples. Neither has wine in large quantities been useful.

When the web of the mucous membrane is affected, or the membranes of the brain, or both, and the disease is of moderate intensity, the old method of treatment is probably to be preferred, or to give salines as long as the tongue is white, aod perhaps to apply a few leeches to the temples if the eye be injected; and as soon as the tongue becomes brown, to support the patient by means of mist. camphoræ, ℥ iſs. c. sp. ætheris nitrici, ʒ j. 6^tis vel 4^tis horis, and at the same time to allow him four to six ounces of port wine with sago, strong broths, &c., daily. If meteorism should take place the linseed poultice should be applied as in the former instance.

Should the disease, however, be decidedly of a low character and bleeding out of the question, and the longs loaded, a powerful stimulant treatment is perhaps to be preferred from the very commencement of the disease. Thus, ten grains of camphor dissolved in two ounces of gin, and given night and morning, whatever were the symptoms, was successful io many of these doubtful cases. Some, also, were treated with salicinæ, gr. v. 4^tis, and recovered; while, in the worst cases, ʒ j. of quinine thrown up as an injection every oight often produced good effects. The linseed poultice, also, was applied with much advantage when meteorism was preseot.

Another practical rule in the treatment of fever is, that when the parotid glands are enlarged, the patieot must be supported from the very commencement with wioe, æther, broths, &c.—at least when the patieot has been differently treated he has died.

In all instances the patient is benefited by checking those secretions which are in excess and restoring those which are in defect. Such are the most general rules for the treatment of typhus fever.

*Dietetic and Preventative Treatment.*—The patient's diet should be strictly farinaceous, with the addition of broths and subacid fruits throughout the whole course of the disease, or until the nates, as they sometimes do, slough, and in that case a mutton chop must perhaps be prematurely hazarded; but its effects should be watched with much caution.

The preveotative treatment includes the three great principles of *cleanliness*, of *ventilation*, and of *separation*. The chlorides or boiling vioegar may mask or destroy smells, but do not neutralize or destroy contagion; for when the Hôpitale Salpêtrière at Paris was used for fever patieots, in the campaign of 1813, even those who superinteoded the fumigations fell ill of the disease. Cleanliness, such as frequent chaoge of linen and the removal of all evacuations, are not only grateful to the patieot, but, by preventing an accumulation of miasmata, are a safeguard to the atteadants. Ventilation has likewise the same good results; and in every case of fever the bed curtains should be undrawn and the door or window occasionally opened for the admission of air. Cleanliness and ventilation also should not be limited to the person of the patient but should extend also to the apartmeot; and, on his recovering, the chamber in which he has lain should be well washed, and such parts as will admit of it be white-washed. It is owing, perhaps, to the neglect of this precaution that fever so fatally prevails in the lodgiog-houses of the poor. One family falls ill of fever, and another succeeds, which suffers the same fate, till the walls become impregnated with the miasmata and the apartment becomes a real focus of infection. Eveo where the party has a permanent habitation, but ill ventilated aod dirty, the same result follows: thus, the Rookery of St. Giles's, the Mint in the Borough, and the narrow courts of Holborn and Whitechapel are hardly ever qoite free from fever. In every epidemic, therefore, it is the duty of the parish authorities to see that the houses of the poorer quarters be cleansed and white-washed. Separation, however, is as necessary as ventilation aod cleanliness; for when fever cases are heaped together fever of a most dangerous character prevails; and even our largest hospitals become, under these circumstances, a focus of pestilence and contagion.

### Of the Poison of Scarlatina.

There are three diseases usually termed the *exanthemata*, in consequence of their principal phenomena being a very marked eruption—namely, the scarlet fever, the measles, and the small-pox. They are re



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markable for being the first diseases of secondary formation we are acquainted with, being supposed to have first originated in Arabia about the middle of the VIth Century. The Arabians first described them, and considered them merely as varieties of one and the same disorder. Many essential differences, however, were soon observed to distinguish the small-pox; but the points of resemblance between measles and scarlet fever were so many, that it was not until many most fatal accidents had occurred from the great error of confounding them, that their differential characters were remarked and their separate identity established. There is one remarkable law, however, common to them all, or that the patient having once had either of these diseases is not again liable to it, his susceptibility to the poison being exhausted on the first attack. We now mean to treat of scarlet fever, a disease from which there died in 1839, in England and Wales, 10,325 persons.

*Remote Cause.*—The original source of the poison is distinctly traceable to Arabia; but as that country is greatly destitute of animal and vegetable matters, it seems impossible to refer its origin to any chemical decomposition of those substances. As the disease has now spread over the whole world, as it prevails at all seasons of the year, is always sporadic, and yet often epidemic, the more probable inference is that it must have a telluric origin.

*Predisposing Causes.*—Scarlet fever has been found to spread more extensively and with greater fatality among the poorer than among the wealthier classes of society. It is twice as fatal in towns as in the country; for in 1838 the mortality in the metropolis was 0·82 per cent., while in England and Wales it was only 0·39 per cent. Again, in 1839 it was 1·131 per cent. in the metropolis, and as 0·67 in England and Wales. Its prevalence also appears to be influenced by season,—at least if we suppose the deaths to be proportioned to the numbers attacked. Thus, in the winter quarter of 1839 there died in the metropolis 207, in the spring quarter 272, in the summer quarter 408, and in the autumnal quarter 637. Both sexes are attacked in nearly equal proportions; or in 1839 5·095 males died, and 5·230 females. All ages are probably liable to the action of this poison, but it is most common to childhood, the feebleness of this early period of life facilitating perhaps the reception of the poison.

It is a law of this disease that, once produced, the infected person of the patient generates a poison which is both contagious and infectious:

*Infectious*, because no susceptible person can remain in the same room, and hardly in the same house, without contracting it. The

*Infecting distance* is consequently much greater than in typhus. Indeed it is necessary to break up every academic establishment in which it prevails, it being hardly possible to isolate children in the same house or school, however large, so as to prevent it spreading. It is likewise

*Contagious*; for children have been inoculated with the serum found in the vesicles which sometimes accompany the rash, and have taken the disease; but the inoculated disease not having proved milder than in the natural way, this mode has been abandoned. Another proof of the contagious nature of scarlatina is, that it has often been propagated by

*Fomites*, as by the clothes and boxes of boys returning from school. Susceptible persons also sleeping in a room lately occupied by patients labouring under scarlatina, and before the furniture has been washed and the bedding and walls well ventilated, have often taken the disease.

*Susceptibility exhausted.*—Dr. Willan says, that out of 2000 cases that he attended, he witnessed no instance of a *second attack*. Still there are some exceptions to this law—Dr. Binns having seen instances of scarlet fever occurring twice in the same party, while Sir Gilbert Blane met with an instance of its occurring thrice in a young lady, without the least suspicion of ambiguity or possibility of mistake.

*Co-exists.*—Scarlet fever has often co-existed with the vaccine disease and with erysipelas, and this poison is consequently capable of co-existing in the system, not only with those that have been mentioned, but probably with all other morbid poisons.

*Modes of absorption.*—This poison is absorbed by the mucous membranes, and also evidently from the fact of inoculation by the skin. Children have been born labouring under this affection, and consequently the poison infects the blood.

*Period of Latency.*—This period varies from a few hours to ten days. In one case inoculated by Rostan, the disease appeared on the seventh day. The disease is probably contagious and infectious as soon as the primary fever has formed, and perhaps till the sore throat has perfectly healed, supposing that affection to continue after the eruption has died away.

*Pathology.*—The theory of this disease is, that the poison having been absorbed, mingled with the blood, and its period of latency completed, acts upon the great nervous centres, deranging their functions, and producing fever. This fever, termed the primary fever, having lasted 24, 48, or 72 hours, does not subside, but the secondary actions of the poison are set up as the peculiar eruption followed, preceded, or accompanied by a sore throat. The eruption runs a given course of six to eight days, but the duration of the affection of the throat is more indefinite, and varies from eight to twenty, or more days. The fever continues during the eruption, and as long as the sore throat exists, but these being terminated, it now subsides, and the disease is ended. In a few instances, however, tertiary actions succeed, as dropsy or inflammation of the joints, diseases quite as formidable as any which had preceded them. As in ordinary fever, the poison of scarlet fever acts on the brain and its membranes, often causing the usual forms of inflammation of those parts.

The law that fever precedes the specific actions of the skin is so general that it has few exceptions, and the pyrexia has been occasionally so severe as to destroy the patient before the more specific actions of the poison have been set up. Again, the law that the great specific action of the poison is on the skin, causing the eruption or exanthema, has likewise only a very few exceptions. Of this eruption there are three kinds, termed by Frank, scarlatina levigata sive plana; scarlatina milliformis sive papulosa; and scarlatina pustulosa sive phlyctænosa vel vesicolaris. These are all evanescent after death, the capillary action of the part continuing after the apparent decease of the party.

The scarlatina levigata is a smooth eruption, in which the surface of the inflamed skin presents no inequality either to the sight or touch. The scarlatina papulosa is when the papillæ of the skin are enlarged, and the

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appearance is that of roughness, or of "goose-skinned." The third form is when the eruption is accompanied by a number of vesicles filled with serum, which ultimately shrivel up and desquamate.

Whatever the form of the eruption, its first appearance is that of innumerable small bright red puncta or maculæ, separated by interstices of healthy skin. These puncta or maculæ quickly become confluent; so that in a few hours the redness becomes general over the parts attacked. The colour, in ordinary cases, is in the first instance a bright red, like that of a boiled lobster, but on the decline of the disease it becomes deeper, and more resembles that of beet-root, while in severe cases it is livid and intermixed with petechiæ. But whatever tint the eruption may assume, it has this peculiarity, that it disappears on pressure, and again returns from the periphery to the centre on that pressure being removed. The colour is also always brighter and more vivid in the flexure of the joints and about the hips and loins than over the rest of the body. The termination of this inflammation is generally by desquamation, and occasionally the squamæ are so large as to preserve entire the whole epidermis of the palms of the hands and of the soles of the feet. Frank has even seen them come away with the hair, nails, and even verrucæ attached. In a few instances, however, the termination is by ulceration.

Whatever be the colour or description of the eruption, it does not attack all parts of the body simultaneously, but appears partially or in a succession of crops; or on the first day it spreads universally over the face, neck, and upper extremities; on the following day over the trunk, but is less general on the back than on the abdomen; and, lastly, on the third day it has extended itself over the lower extremities. The duration of each crop is about three days, when it disappears, and in the order of attack, fading from the head and upper extremities on the fourth day; from the trunk on the fifth day; and from the lower extremities from the sixth to the eighth day. The order of attack, however, which has been mentioned is not constant, for in some few instances the eruption appears first on the trunk and lower extremities, and only on the second day very faintly on the face and upper extremities.

The poison as frequently falls on the mucous membranes of the eyes and nasal fossæ as on the skin, and excites a similar eruption over those parts; at first consisting of a similar distinct punctuated or dotted appearance, which changes in a few hours to one diffuse red. The inflammation of the ocular membrane, however, has this peculiarity, that it does not distress the sight, for the eye bears light without inconvenience, and in no case is it suffused with coryza. Neither is sneezing a consequence of the affection of the nasal membrane; and only in a few severe cases is there any discharge from the nostril. As the eruption attacking these parts generally appears with, so does it generally die away with, the first crop of the exanthemata of the skin. This inflammation usually terminates by resolution; but in a few instances the alæ of the nose ulcerate, and sometimes mortify.

The lingual and buccal mucous membranes are also often the seat of a similar exanthema, presenting nearly the same appearance as in other parts. The papillæ of the tongue, however, are singularly elongated and enlarged, and stand up salient and erect, and of a deep scarlet colour above the thick white mucus which coats the lingual membrane, and hence the term "strawberry tongue." This affection lasts longer than the former, and usually terminates by resolution, though in a few instances the buccal membrane ulcerates and mortifies.

The sore throat, or inflammation of the faucial membrane, though not so constant an affection as that of the skin, yet, when it does exist, is often of much longer duration, and is a much graver disease, and it may either precede all the other symptoms, or else occur at any period of the fever. This inflammation, at first punctuated, then diffuse, usually runs into ulceration; and the character of the ulcer is so completely in unison with the state of the constitution as to enable us, according as it is slight or severe, to divide scarlatina into two great varieties, or into scarlatina mitior and into scarlatina gravior. The first, or sthenic form, is marked by a greatly enlarged or swollen state of the tonsils, which are of a vivid or bright red colour; and, when ulceration takes place, the ulcers are seldom deep, or the sloughs slow to come away, but usually separate about the fifth or sixth day, so that in mild cases the sore throat is healed about the eighth or tenth day, or in more severe ones about the fifteenth or twentieth. In malignant cases, or in scarlatina gravior, the tonsil is much less tumefied and enlarged, but is much more loaded with blood, and is of a deeper and sometimes of a livid colour. The ulcers also are deep and formidable, and the sloughs are thrown off later in the disease. They are likewise slow to heal, or not till the end of three weeks, or in severe cases not till four or even six weeks have elapsed, during which period the fever continues and the patient lies in considerable danger.

The inflammation of the throat may extend to all the neighbouring parts, and an abscess may form in the pharynx, or pus issue from the ears; the tympanum has been eroded, and in a few instances the inflammation has extended to the larynx, and the patient has died of croup. Besides these disorders the glands of the neck often enlarge and occasionally suppurate, and, singular to say, sometimes not till after the sore throat has healed, and sometimes when there has been no previous affection of the throat, as if these parts were the seat of a specific action of the poison.

The inflammation of the cutis, as also of the buccal mucous membrane, is usually accompanied by some inflammation of the sub-cellular tissue. This affection takes place as soon as the rash appears, and causes the hands to swell, so that the patient is unable to bend his fingers, and his face also becomes tumefied and painful. The serum effused, however, is in mild cases absorbed, and the disease terminates without any unpleasant consequence. In severe cases, however, it has a tendency to terminate in ulceration or in mortification. In one child the toes of the right foot had sloughed off; in another the integuments of the leg mortified from the knee to the foot; while, in a third, mortification commenced in the upper lip, and spread till one-half the cheek was eaten away. Some have been known to die of mortification of the rectum, and others of a similar affection of the pudenda.

Such are the primary and secondary affections of scarlatina; but this poison has also some tertiary actions, as on the cellular tissue, causing dropsy, and on the synovial membranes of the joints.

The dropsy which sometimes occurs after scarlet fever must be considered as a tertiary action of the poison. This usually commences between the fifteenth

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and twenty-third day of the disease, and almost uniformly not till after all the other symptoms have subsided. It begins with anasarca of the face, afterwards attacking the hands and feet. In some instances the anasarca is universal, the whole cellular tissue filling so rapidly as sometimes to destroy the patient in a few hours, the cavities of the chest and abdomen frequently filling at the same time. When the patient has fallen from this dropsy the kidneys have in general been found healthy, although albuminous urine has been secreted during life.

The inflammation of the synovial membranes has been described by Withering, Sennertus, Heberden, Murray, and others. This disease may attack the wrist, ankle, or knee-joints, and usually terminates by effusion of serum; but in two cases that died at the London Fever Hospital the joints contained pus. This inflammation seldoms occurs till after the eruption has subsided, and is therefore the result of a tertiary action of the poison.

Such are the morbid appearances which have been observed in scarlatina, and with sufficient constancy to be attributed to a specific action of the poison; but these appearances are only to be found when the disease is of moderate intensity and the patient survives some days, for in severe and rapid cases the patient dies, not from any organic lesion, but from the intensity of the poison,—for Bretoneau, Tweedie, and Sims all speak of having examined the bodies of persons who have fallen early in the disease, in which there was scarcely any appreciable lesion. Besides these lesions peculiar to the action of the poison of scarlatina, must be added those inflammatory appearances of the brain and its membranes which are common to fever generally.

*Symptoms.*—The varieties of scarlet fever arise out of the law, that poisons may exhaust themselves on one or more tissues they affect without involving the whole series. Thus, the poison of scarlet fever usually acts on two membranes, or on the skin and mucous membrane of the fauces; but its actions may be limited either to one or the other of these membranes. Assuming, then, that the term scarlatina should be applied to the most usual form of the disease, or to the affection of the two membranes, the classification of the varieties would be thus—

Scarlatina,
Scarlatina sine eruptione,
Scarlatina sine angina.

Scarlatina also may be either mild or severe, and hence we have the gradations of—

Scarlatina mitior, and
Scarlatina gravior.

Scarlet fever, of whatever description, essentially consists of fever and certain local inflammations; but among the more striking phenomena of this disease, as in typhus fever, is the sudden and remarkable depression of the moral and physical powers of the body which the poison produces,—a depression so great as sometimes to cause the death of the patient in a few hours, without any re-action or any very sensible local lesion of the throat or other part being discoverable after death. On the contrary, there are a few instances in which the re-action is so great as to destroy the patient in an equally short time, and with a similar absence of all pathological phenomena, the affection of the skin being suppressed, the sore throat wanting, and the patient falling as from an overwhelming poison.

The symptoms of scarlet fever under ordinary circumstances may be divided into three stages. The first stage occupies the period from the commencement of the disease till the appearance of the eruption, and is technically termed the "*primary fever*." The second stage, that from the appearance of the eruption till its entire subsidence; while the third stage is reckoned from the disappearance of the eruption till the termination of the disease. The duration of the first stage is twenty-four, forty-eight, or seventy-two hours; that of the second from six to eight days; while the third stage may either not exist, or vary from a few hours to two or three weeks, making the whole duration of the fever to vary from eight to thirty or more days. These stages are not, as in typhus, usually marked by changes of the tongue, for, except in scarlatina gravior, it continues coated with a white mucus throughout the whole course of the disease. In scarlatina gravior, however, it becomes brown or black in the second or at the commencement of the third stage.

The primary fever may be sudden in its attack, or the patient may complain for some days of slight indisposition. Its symptoms, whatever be the variety, are those of the first stage of typhus,—as headache, pains in the back and loins, loss of appetite, sickness, and white tongue. Still there are symptoms which distinguish it from ordinary continued fever, for the pulse, instead of being full and strong, is small and weak, and rapid, and the heat of the skin more ardent, and these phenomena continue through the whole course of the disease. The fever varies, however, greatly in intensity, or from a mere febricula to the severest forms of typhus.

*Scarlatina sine angina* is the simplest form of scarlet fever, and is limited to the fever and eruption, without any affection of the throat.

The symptoms of this variety are extremely mild, so that the patient is frequently not confined to his bed. The primary fever, except that the pulse is rapid, is little more than a mere febricula, and is not aggravated on the appearance of the eruption. The eruption appears at the end of twenty-four or forty-eight hours, and the crops follow each other according to the usual order of succession, appearing first on the face and neck and upper extremities; on the following day on the trunk; and on the third day on the lower extremities, when the disease has reached its acmé. On the fourth day the rash begins to decline, and fades from the face, neck, and upper extremities; on the fifth day it disappears from the trunk; and on the sixth or seventh day it is evanescent over the whole body. The colour of the rash is always more florid during the night than in the day, and on its declining desquamation takes place. With the disappearance of the rash the fever of this variety ceases, and the disease terminates; but it often leaves the patient in a state of considerable debility for several days.

*Scarlatina sine eruptione.*—In this form of the disease also the specific action of the poison is limited to one tissue, or that of the throat, the eruption on the skin being altogether wanting.

There is seldom a season in which scarlatina has been in any degree epidemic, that cases have not occurred in which patients not having previously had the scarlet fever are seized with severe fever and sore throat, unaccompanied by any eruption, and who, on subsequent exposure to the contagion of scarlatina, have been found insusceptible of the action of the poison; and hence it is inferred the disease they have passed

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through, must have been a variety of scarlet fever or scarlatina sine eruptione.

This disease therefore essentially consists in fever and sore throat. It has been stated that the state of the throat was constantly in unison with the state of the constitution, and consequently this form of disease, according to its severity, assumes all the symptoms which accompany scarlatina mitior or scarlatina gravior, with the exception of the absence of the eruption. It seems unnecessary therefore to give a separate detailed account of this variety.

*Scarlatina Mitior.*—The essential character of this variety is, that the secondary or specific actions of this poison fall on two tissues, or on the skin and on the mucous membrane of the eyes, nose, mouth, and fauces. This form is liable also to the tertiary actions of the poison, but in what proportions have not as yet been determined. It is distinguished from scarlatina gravior by the more enlarged and hardened state of the tonsils.

The fever which precedes the eruption in scarlatina mitior lasts from 24 to 72 hours. The symptoms, however, are more violent than in the preceding species; for nausea or vomiting, great restlessness, headache, and some delirium frequently occur as early as the second day. The heat of the skin also is more considerable, and often raises the thermometer as high as 105°, while the pulse is quick, feeble, and fluttering, and shows the extreme debility the poison has occasioned. The primary fever having lasted its period, the specific actions of the poison are set up, and the eruption runs the course which has been described in scarlatina sine angina, but its colour is more intense, its duration more variable, and its attack more partial.

The *angina*, so marked a symptom in this affection, may precede the primary fever, may commence with the eruption, or may occur at some later day in the disease. It has many grades, and in this form of scarlatina they are all sthenic. Thus, in slight cases the throat has merely the sensation of roughness, with some pain in deglutition; at a higher degree the tonsil is enlarged and ulcerated; while in cases of still greater severity they are swollen to a degree almost to occlude the fauces. In this latter case the act of deglutition is not merely painful, but in many instances impossible, and impeded by a thick viscid mucus, which frequently requires the effort of vomiting to remove. The irritation of the fauces is sometimes propagated to the larynx, and the patient is hoarse or inaudible, and perhaps ultimately fails from this new affection. The parotid and submaxillary glands also often enlarge, sometimes previously to the sore throat, more commonly about the fifth day, and again after the sore throat has healed. In a case recently treated at St. Thomas's Hospital, these glands, singular to say, began to enlarge about the 14th day, without the patient having had any antecedent or accompanying sore throat, as though this affection was the result of a specific action of the poison.

The degree of fever is usually proportioned to the severity of the angina, and is accompanied by headache and sometimes by delirium. It does not abate on the appearance of the eruption, but continues till the throat is healed. If the sloughs come away early, or on the fourth or fifth day, the throat heals, and the fever perhaps subsides within a day or two after the eruption. It sometimes happens, however, that the sloughs do not separate till the fourteenth or fifteenth day; and in this case the fever runs on with equal violence after the disappearance of the eruption, and the whole disease is sometimes prolonged for three weeks or a month. In this case the tongue may become brown or dry, but it seldom continues so for more than a few hours.

*Scarlatina Gravior.*—The specific actions of the poison in this form of the disease are the same as in scarlatina mitior, but the symptoms, both local and general, are more severe, and the tertiary affections more frequent, and consequently the disease is more grave and the danger more formidable.

The more remarkable symptom which distinguishes this form of the disease is the state of the tonsils. In the scarlatina mitior it has been stated that the tonsils are either slightly affected or greatly enlarged, of a bright red, and the ulcers comparatively superficial; but in this severer form the tonsil, though less swollen, is more gorged with blood, more livid in colour, while the ulcers are foul, deep, and burrowing; the secretions of the mouth also are more copious, and generally impregnated with the offensive sordes of the sloughs; while deglutition, if less difficult, is perhaps infinitely more painful, and the mouth often so tender that the slightest touch excoriates it. The ulcers likewise are slow to granulate, and only heal after a fearful struggle; and in the worst cases they spread in every direction, and the parts vesicate and mortify previous to the death of the patient.

The eruption also offers some peculiarities, being often later, by some hours, in coming out, its colour darker and more livid, its duration more uncertain, and its distribution more irregular and capricious than in scarlatina mitior. The primary fever likewise is usually longer, the delirium earlier, and the depression more complete than in the milder forms, and towards the close of the disease the tongue becomes brown, and the symptoms closely resemble those of the last stage of typhus fever.

Such are the more marked characters of scarlatina gravior; but it often happens that the progress of this disease is silent, slow, insidious, scarcely marked by any prominent symptom, till the degree in which the constitution is subdued by this formidable poison is shown by the inflamed nasal membrane discharging its fatal ichor, causing mortification of the alæ of the nose, or else mortification of the lip or cheek, or else it seizes on some remote part, as the toe, the leg, or the whole of a lower extremity, and which for the most part terminates the life of the patient.

The tertiary actions of the poison of scarlatina are inflammation of the joints and dropsy, and it is singular that these diseases are more often set up after mild than after the more severe forms of this fever. In a few cases, then, about the time of the disappearance of the rash, the joints of the wrist or fingers, of the knees or other articulation, become swollen and inflamed, and present all the phenomena of an attack of acute rheumatism. This affection keeps up the fever and prolongs the whole duration of the disease for many days beyond the usual period.

Again, in a given number of cases, not exceeding three per cent. in general, but in different seasons, or under different treatment, sometimes amounting to twenty per cent., the tertiary action of the poison produces dropsy. This disease usually occurs about the twenty-second or twenty-third day, or about the time when the patient is convalescent, and more often after a mild than after a severe disease, Dr. Wells never having seen it follow "the putrid sore throat." This affection more commonly begins with œdema of the face,

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then the hands and feet swell, and, in a few cases, the trunk and lower extremities become enormously distended, and the patient presents a frightful appearance. When the cellular tissue is thus slightly or more generally distended with fluid, effusion may take place into the cavities of the head, chest, or abdomen. When the brain is threatened, the effusion is commonly preceded by the usual hydrocephalic headache, by convulsions, and sometimes by blindness. Effusion into the cavity of the chest or of the abdomen causes the usual symptoms of hydrothorax and of ascites, which have been described, and need not be repeated. In the former instance, however, the water is sometimes poured out so rapidly as to destroy the patient in a few minutes or in a few hours.

The first appearance of the œdeme, whatever form of dropsy may follow, is usually preceded or accompanied by an accelerated pulse, by the urine being scanty, commonly turbid, and passed with pain; the quantity, however, is shortly increased; and if examined when passed copiously, it is found to be of low specific gravity, or from 1·011 to 1·017, and to contain albumen.

*Diagnosis.*—The only diseases with which scarlatina can be confounded are the acute forms of roseola and measles. Roseola, though usually accompanied by fever and sore throat, yet is distinguished from scarlatina by the eruption being confined generally to the chest. The diagnosis between measles and scarlatina will be better understood after the laws of measles have been described, and will therefore be best treated of in the diagnosis of *measles*.

*Prognosis.*—The mortality from scarlet fever varies greatly according to the season, and also perhaps according to the *treatment*. In some years the proportion of deaths is not greater than three per cent.; but Sir Gilbert Blane says his practice gave one in four; but he probably was consulted only in the worst cases, for in the same year it appears, from the reports of other practitioners, the deaths varied from one in six to about one in thirty, according, perhaps, to their different modes of treatment.

*Treatment.*—Scarlet fever being evidently accompanied by many highly inflammatory symptoms, the practice of bleeding was adopted on the first breaking out of the disease in all countries, and, according to Willan, with the most disastrous results. The practice of bleeding was adopted by Morton; and he speaks of witnessing 300 deaths from scarlatina in a week. It prevailed also down to the times of Huxham, who abandoned it and introduced a treatment by bark. In this manner an entirely opposite system of treatment has been introduced, and the records of medicine enable us to state the results of these opposite modes of treatment: Of 121 cases treated at the Foundling Hospital

| | Died. |
|---|---|
| by bleeding, in 1786. . . . . . | 19 |
| 60 cases treated at the London Fever Hospital in 1829, in the same manner . . | 10 |
| 181 | 29 |
| or 1 in 6 nearly. | |
| 200 treated by wine, mineral acids, &c. . . . | 2 |
| 160 ditto by purgatives and emetics . . . | 16 |
| 50 ditto ditto . . . . . . | 3 |
| 45 ditto ditto . . . . . . | 1 |
| 100 wine and mineral acids . . . . . . | 3 |
| 555 | 25 |
| or nearly as 1 in 22. | |

It seems therefore proved, that one in six has died after bleeding, while only one in twenty-two has died after a milder, if not a directly opposite, mode of treatment; and the conclusion which inevitably follows is, that the chances of recovery are diminished by the practice of bleeding nearly in the ratio of four to one as compared with the chances of recovery, supposing the patient not to have been bled. It remains now to give some general directions for the treatment, and to point out the circumstances in which bleeding, purgatives, wine, and tonics may be most advantageously employed.

It should be laid down as a maxim, that in scarlatina medical advice ought always to be had recourse to; for the worst cases we meet with, as mortification of the nose, cheek, or limb, are those in which the disease has, from its apparently mild character, been left to itself.

In the scarlatina sine angina, the mildest form of the disease, it is often sufficient to confine the patient to the house; to strictly enjoin a milk diet; to regulate the bowels; and, above all things, to avoid the nimia diligentia medicorum. If anything more be done, a small quantity of wine and water, proportioned to the age of the patient, is the best. The disease thus treated is uniformly mild, and when the rash declines the fever subsides, and the disease is at an end.

The treatment of the scarlatina sine eruptione is the same as that of the two following varieties, or that of the scarlatina mitior and the scarlatina gravior.

The treatment of scarlatina mitior, or when the tonsils are considerably enlarged, is first to tranquillize the stomach and allay its inverted action when vomiting exists, either by small doses of the sulphate of magnesia or by the effervescing draught,—medicines which, according to the state of the bowels, may be exhibited every four or every six hours. As soon as this object is effected, and it is ascertained that the tonsils are greatly enlarged and swollen, the practice, supposing the patient to be an adult, is to relieve them by a local bleeding, and twelve to fifteen leeches should be applied to the throat, and allowed to draw freely, and this bleeding may be further encouraged by the application of a poultice. The trifling loss of blood thus sustained does not impair the general strength of the patient, while it greatly reduces the swelling of the tonsils and prevents their becoming permanently enlarged. Another advantage is also gained by the application of leeches to the throat, namely, that they relieve the affection of the head; for we constantly, in diseases depending on morbid poisons, often relieve the head by relieving the part specifically acted upon.

The tonsils having been relieved, the fever may now be permitted to run its course little influenced by medicine, and the patient only refreshed by the occasional exhibition of the saline draught so grateful to his parched mouth and feverish state. For in these cases if we stimulate the patient, we only bring back the tumefaction of the tonsile; while, on the contrary, if we take more blood we hazard producing the more serious accidents incident to scarlatina gravior. The medicines, therefore, that have been mentioned should be persevered in till the disappearance of the eruption, and till the healthy granulations of the throat and the decline of the fever give the certain evidence of a state of convalescence. At this point perhaps some mild tonic medicine, as the infusi aurantii c. tinct. aurantii, is desirable, and prepares the patient once more for the fullest

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Elementary Principles of Medicine.

enjoyment of health. This is the most successful treatment of scarlatina mitior.

The scarlatina gravior is characterized by the less swollen state of the tonsils; by their being more livid and gorged with blood; by the ulcers being deeper and more spreading; and by the slough being fouler than in the former variety. In this form, as there is a greater tendency of parts to run into mortification, the necessity of adopting a more stimulating plan of treatment, and one more calculated to support the powers of the constitution, is manifest, and experience has shown this view of the case to be correct. A treatment by wine, which is much more easily digested than most medicines, therefore should be the basis of the cure. The quantity of wine for an adult is from four to six ounces in the twenty-four hours, and for the child about half that quantity. The wine may be either port or sherry, and should be drank in small quantity, mixed with two-thirds water; or it may be given with sago, arrow-root, or other slop. The earlier the wine is given in the disease the better, and when delirium does or does not exist, or whether the tongue is moist and white, or brown and dry, and it should be continued till the patient is decidedly convalescent, and even for some time after. While pursuing this plan it is necessary that the patient's bowels should be attended to. This treatment by wine is extremely successful; and, as it is in general pleasant to the patient, whether a child or an adult, it is seldom refused. Most persons, however, are fond of medicine, and have great faith in it; and in these cases an equivalent may be substituted, as the disulphate of quina, gr. j. to gr. ij. 6[ta] horis, or the infusi aurantii c. tinct. aurantii, ℥ iſs. 6[ta], or salicine, gr. v. 6[ta] vel 4[ta]. The decoctum cinchonæ c. acidi sulphurici dilut. ♏v. to x. 6[ta] horis, is also another efficient remedy.

In cases where, from the state of the throat, it is difficult to decide whether the treatment by wine or by leeches should be adopted, the former is always preferable; for, in case of error, it is easy to detract blood, but we cannot with the same certainty give the patient power.

The treatment of the tertiary affections of the poison is very various. Thus the affection of the larynx is one of the most important; and it is singular that although this affection would seem to be of an inflammatory character, yet bleeding is not successful in combating it; on the contrary, the most beneficial mode of treatment appears to be that of moderately supporting the powers of the patient by wine and mild tonics.

Again, when the synovial membranes inflame, and the joints become enlarged and swollen, all stimulus should be withdrawn; but bleeding in this instance also appears unnecessary; a moderate action, however, of the bowels should be kept up by means of the sulphate of magnesia ʒ ß. to ʒ j., out of camphor mixture; and, should the pain be severe, some opiate should be added, as ♏ xv. of the tinct. hyoscyami. Mr. Murray thinks so lightly of this affection that he says it was commonly removed in Aberdeenshire by warm fomentations.

The more formidable affection in scarlatina is dropsy; and from the great tendency to effusion into the head and chest, an active treatment is necessary. We should have imagined that in dropsy, a symptom in most cases of great debility, and following a disease whose characteristic is great depression, bleeding would have been dangerous and improper; but experience has shown that bleeding is at all times a prudent, if not a necessary measure: as soon, therefore, as œdema appears in the face, especially if accompanied by headache, some blood should be taken, or from 2 to 4 ounces in the child, and from 8 to 12 ounces in the adult. The rest of the treatment consists in purging the patient. The choice of the purgative must rest with the practitioner; but the bitartrate of potash in ʒ j. doses three times a day is among the most useful; digitalis also is much recommended, but it does not possess any specific virtue. When the danger is passed, 5 grains of salicine, or 5 to 10 grains of the tartrate or citrate of iron may be added to each dose of the salt.

Blisters have been much recommended as a means of relieving the throat, but their value is not yet determined. Some writers speak of mortification and death following their application, while others consider them as powerful auxiliaries. As a general principle they are unnecessary, and are better omitted; since the irritation they occasion may predispose the cervical glands to the tertiary action of the poison.

Gargles are unnecessary for children, for they cannot gargle, and they are rarely necessary for adults.

*Dietetic and Preventative Treatment.*—The diet of the patient should be slops, light nutritious broths, and jellies. Fumigation will not, it should be remembered, destroy the miasmata in the sick room; and consequently the doctrine of cleanliness, of ventilation, and of separation, are as imperative in this disease as in typhus. We cannot disinfect the walls of the chamber, nor the clothes of the patient, except by washing them, or else exposing them to a dry heat exceeding the boiling temperature. In general, then, the chamber where the sick patient has lain should be white-washed and well scoured after the disease has subsided, before any person susceptible of the poison be allowed to sleep in it.

### Of the Poison of Measles.—Morbilli.—Rubeola.

The measles are a continued febrile disorder, with certain local lesions, but more especially a peculiar inflammation of the skin, which runs a given course. This poison has the property of exhausting the susceptibility of the constitution to its action on the first attack. The number of persons that died of this disease in 1839 in England and Wales was 10,927.

*Remote Cause.*—The measles appeared at the same time and in the same country with scarlet fever, and have subsequently followed the same laws, namely, they now prevail all over the world, are little influenced by season, are constantly sporadic, and occasionally epidemic. Their poisons, it would appear, must consequently have a similar or tellurie origin.

*Predisposing Causes.*—Measles, though incident to every period of life, are most frequently contracted in childhood, when it is difficult to trace the effects of accidental circumstances, so that our knowledge of the predisposing causes are most imperfect. Both sexes, however, appear to be equally liable to this affection. With respect to the influence of season, it is generally supposed that measles break out in the beginning of winter, increase till the vernal equinox, and then die away towards the summer solstice. The deaths, however, from this disease, registered in England and Wales in the years 1838, 1839, and 1840, show that the influence of season is exceedingly trifling. Thus there died in—



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| | January February March | April May June | July Aug. Sept. | Oct. Nov. Dec. |
|---|---|---|---|---|
| Deaths from measles in 3 years. . . | 6932 | 7157 | 5543 | 6945 |

It is admitted by all authors that a patient lebouring under measles generates a poison which is both infectious and contagious.

*Infectious.*—This disease, like scarlatina, is greatly infectious; and in like manner no susceptible person can remain in the same room, or even in the same house, without hazard of taking the disease. In the year 1824 it was imported into Malta by some children belonging to the 95th regiment, and spread extensively in that island, so that many natives died. This circumstance was the more remarkable, as the measles had not been seen in the island for many years. The *infecting distance* of this poison, it will be plain from what has been stated, must be considerable; indeed it is impossible to isolate it in our public schools or other large establishments.

*Contagious.*—The contagious nature of measles has often been proved by healthy children having been inoculated either by blood drawn from the arm of a measly patient, or else with serum taken from the vesicles which are occasionally found intermixed with the eruption,—an experiment which appears to have been first made by Dr. Home, with a view to producing a mild disease but as no such result has been obtained; the practice has been abandoned.

*Fomites.*—This disease is also propagated by fomites. The strictest demonstration of this law is, that the disease has been communicated by direct application of substances impregnated with the virus, in the attempts to inoculate for the measles; it is also proved by the clothes and boxes of children sent home from schools, where the disease has raged, communicating the disease; and also by the same circumstance resulting when susceptible children have lain in the same beds, or in the same room, shortly after it has been occupied by measly patients.

*Susceptibility exhausted.*—The morbillous poison having once produced its specific effects, as a general principle leaves the patient exempt from all liability to a second attack. This law may be considered as proved both by Willan and Rosenstein—the former affirming that after an attention of more than 20 years to eruptive complaints, he had not met with an individual who had twice had "febrile rubeola;" while the latter states, that in a practice of 44 years he had met with no instance of a second infection. There are, however, occasional exceptions to this law; one whole variety of this disease, or the rubeola sine catarrho, is supposed to afford no protection against an attack of the rubeola vulgaris. There are many exceptions also to the non-susceptibility of persons who have passed through the rubeola vulgaris, for Burserius, Robedieu, Hume, Baillie, Rayer, and Holland have all seen instances of a second attack of the measles in the same individual.

*Period of Latency.*—The period of latency of this poison is determined to vary from 10 to 16 days. It seems also determined that the contagion of measles is generated as soon as the primary fever is established, and before the eruption appears.

*Pathology.*—The theory of measles is, that a poison is absorbed and infects the blood, and after a given period of latency acts on the great nervous centres, producing a continued fever, which does not remit on the appearance of the eruption, but runs on throughout the whole disease. The fever thus being established at the end of three, more generally of four, and in some few instances of five days, a certain secondary or specific inflammation of the skin and of the mucous membranes of the eyes, nose, mouth, fauces, and bronchi is set up in addition to the fever. In a few cases the poison has certain tertiary actions, and produces inflammation of the substance of the lungs, or of the pleura. As the primary fever lasts from three to five days, and the eruption from six to seven days, the whole duration of the disease is from nine to twelve days. Whenever the tertiary actions occur, the disease is much prolonged.

The law that fever precedes the specific actions of the poison has scarcely a recorded exception; and consequently, though the pyrexia may greatly vary in intensity, it is uniformly present. The fever which precedes the local lesions is termed the primary fever.

The second great law of the poison, or that its secondary actions are on two membranes, or on the skin and mucous membranes, has some exceptions; for the affection of the mucous membrane is entirely wanting in one variety, or in the morbilli sine catarrho. The law that the poison produces certain tertiary actions, as inflammation of the lungs, or pleura, is so well determined that it requires no proof, but we must regret that their proportional frequency is not ascertained.

Since the affection of the skin is uniformly present, while that of the mucous membranes is sometimes absent, the cutaneous eruption is necessarily the great characteristic of the disease; but the morbillous eruption being evanescent after death, we can only imperfectly trace its pathology. It first appears as a circular dot, similar to a flea-bite, slightly prominent, and sensible to the touch. Its colour is of a deep raspberry hue, and in rare instances, as in the morbilli nigri, is livid or black. In severe cases, also, especially if the patient be of tender age, the exanthema assumes a papular form, and when at its height, occasionally a vesicular form; and the latter is most common on the arms, the neck, or the breast. The colour of the exanthema is evanescent on pressure, but returns on the finger being removed.

The patches of the exanthema are extremely numerous, so that they leave little of the healthy skin intervening between them; and they not unfrequently become confluent, and form large maculæ, sometimes of a semi-lunar form. The principal seats of the exanthema are the face and back, while the parts least affected are the pudendal and popliteal regions. The inflammation attending the exanthema extends in some degree to the subjacent cellular tissue, for the face is tumid and swollen, but not so as to close the eyelids.

The eruption does not at once cover the whole body, but consists of three crops, each of which follows the other at an interval of twenty-four hours, the duration of each crop being three to four days. The course of the measles then is, that on the third or fourth day of the primary fever the first crop appears on the face, neck, and upper extremities; on the following day, the second crop covers the trunk; and on the third day the third crop appears on the lower extremities, so that the whole body is full of the eruption, which is now at its

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Elementary Principles of Medicine.

height. On the following day, the fourth of the eruption, the exanthemata begin to decline from the face, neck, and upper extremities; on the following day they fade from the trunk; and on the sixth or seventh day, they are evanescent over the whole body. They uniformly terminate by resolution, followed by a furfuraceous desquamation of the cuticle of the body generally.

The inflammation of the mucous membrane, of the eyes, and nasal fossæ, generally commences either with or before the primary fever, and consequently precedes the eruption by some days. This inflammation is perhaps for a few hours puliose, then diffuse, but quickly changes to the serous; for a profuse watery discharge from the eyes and nostrils shortly follows, termed the "coryza." This affection usually continues till the decline of the eruption, and in some cases later.

The mucous membrane of the mouth and fauces also inflames, but the inflammation differs from that of the eyes and nose in not being accompanied by any discharge. In other respects it is exactly similar to the cutaneous eruption, for a number of exanthemata, more or less confluent, are seen upon the palate, uvula, tonsils, and velum pendulum palati, and they equally terminate by resolution. They appear also at the same time with the eruption on the face, neck, and upper extremities, but do not decline till the eruption fades from the body generally.

The bronchial and tracheal mucous membranes are usually attacked, either before or at the same time with the buccal membrane, but whether the inflammation of which they are the seat is marked by the same characteristic eruption is not determined, for few patients fall at this early period of this disease. The cough and expectoration, however, which accompany it are constant, and the latter shows that it partakes of the same serous character as that of the nasal and ocular membrane. Again, towards the close of this disease, or even as late as the third or fourth day after the eruption has disappeared, the poison not unfrequently falls on the substance of the lungs or pleura; supposing it to fall on the substance of the lungs, it usually excites serous inflammation of that tissue, and the quantity of fluid effused is frequently so considerable as to stream from the lung as soon as its tissue is divided. In severe forms of the disease the poison may produce either the red or grey hepatization of the lung, but these results are rare. The pleura does not at all times escape the action of the poison; and the diffuse, the serous, the adhesive, and even the purulent inflammation may invade that tissue, and either destroy the patient or prolong his convalescence. Diarrhœa also is often an accompaniment of this disease, which renders it probable that the mucous membrane of the intestines may be the seat of a specific action of the poison.

*Symptoms.*—The symptoms of the measles result from the fever, and the consecutive local lesions. The varieties of the disease, however, are extremely few, for no instance is known of a morbillous fever without the secondary or specific actions following; but the poison is supposed sometimes to limit its action to one membrane, or to the cutis, and to exhaust itself on that tissue; and hence, the morbilli sine catarrho. The varying intensity also of the morbilli enables us to divide them also into two grades, or into the morbilli mitiores, and into the morbilli graviores. The arrangement, therefore, of the forms of this disease will be as follows:—

*Morbilli sine Catarrho.—Morbilli mitiores.—Morbilli graviores.*—The primary fever may make its attack suddenly, or be preceded for a few days with symptoms of a common cold, and in general the latter is the case; but in no instance is the primary fever, which is afterwards prolonged, and accompanies the eruption at any time, of great intensity; for although many fall from the severity of the local lesions, yet no instance is known of the patient being overwhelmed or destroyed by the general depressing action of the poison, as in typhus fever or in scarlatina. The depressing powers of the poison, however, are considerable, and are always sufficient to confine the patient to his bed for a few days, and to leave him, for a short time after the disease has subsided, weak and debilitated. The type of the fever of measles consequently greatly differs from that of typhus or of scarlatina, and the formidable brown tongue, so grave a symptom in the latter, is hardly known in the former, or only seen in a few fatal cases.

*Morbilli mitiores.*—The essential characters of this affection are, that the poison produces primary fever, and a specific inflammation of two membranes, as of the skin and mucous membranes, the fever not subsiding till the eruption dies away.

The symptoms of the measles may be divided into three stages; the first embraces the primary fever, or the period before the eruption, and may last from three to five days; while the second stage embraces the period of the eruption, and lasts from six to seven days. These two stages very commonly comprise the whole disease, whose usual course is from nine to twelve days. The third stage includes any inflammatory action which may be caused by the tertiary action of the poison, and therefore only occasionally exists.

The early symptoms of the primary fever are seldom severe, and greatly resemble those of an ordinary but severe catarrh. They are shivering, alternated with heat, frequent pulse, headache, derangement of the bowels, sometimes accompanied by nausea and vomiting; and these affections are so considerable that the patient usually takes to his bed. At the end of a few hours the fever becomes continued, and the specific action of the poison commences by the mucous membrane of the eyes and nose inflaming, so that the light is painful; the senses of smell and taste are lost, and this is followed by a copious discharge of serum from the nose and eyes.

The buccal and bronchial membranes may become affected at the same time, and the patient is then troubled with a frequent cough, which, according to Frank, has this peculiarity, that it occurs in paroxysms. The cough does not remit till about the seventh day, and is often accompanied by hoarseness, by a sense of constriction across the chest, by diarrhœa, and sometimes by ischuria. The duration of this first stage is three, four, or five, and Home states he has seen it last six days.

The second stage commences with the appearance of the eruption whose course and character has been described. On the appearance of the eruption the fever is often aggravated, but the distressing nausea and vomiting seldom last beyond the fourth day. The fever, therefore, together with the coryza, sneezing, coughing, hoarseness, and diarrhœa, continue with unabated severity till the eruption has reached its height, and is full out over the whole body, which is on the third or fourth day after its first appearance. From this period, in



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favourable cases, all the symptoms begin to decline; and on the eruption disappearing the cuticle desquamates, and the disease terminates on the ninth, tenth, or eleventh day from its commencement

In a few cases, however, on the subsiding of the eruption, or about the ninth, tenth, or eleventh day of the disease, and in some instances earlier, the tertiary actions of the poison are set up, and inflammation of the substance of the lungs or of the pleura takes place, prolonging the duration of the disorder, and endangering the life of the patient. The inflammation of the bronchial membrane is denoted by the expectoration either of a thick viscid mucus or of pus, and which may or may not be streaked with blood, while the mucous or sonorous rattle will point out the peculiar seat and extent of the mischief. If the substance of the lungs be inflamed the breathing is more difficult, the cough more troublesome, and the countenance livid; but the loud mucous rattle which accompanies it seldom allows us to hear crepitation, or to determine the absence of respiration in any given portion of the lung. If the pleura be inflamed, we have, in addition to the cough, severe pain in the side—the *point de côté*, and the impossibility of filling the chest, except in a very limited degree; and this is often accompanied by dulness on percussion, by bronchophony or ægophony, assuring us that fluid is effused into the cavity of the chest.

*Morbilli graviores.*—The characteristic of this severe form of measles is the exanthemata becoming suddenly black, or of a dark purple with a mixture of yellow. The early writers on measles describe this form of the disease as being much more common in their times than we find it to be in the present. Sydenham considers this appearance as extremely formidable, and that persons so seized are irrecoverably lost unless they are immediately relieved by bleeding and a cooler regimen. Willan says he has seen this discoloration, but thinks more lightly of it.

*Morbilli sine catarrho.*—When the measles have been epidemic, a few cases have been observed in which the fever and cutaneous eruption have constituted the whole disease; the mucous membranes being altogether free from coryza or other form of inflammation. Frank rejects this form as spurious, because it does not protect the constitution from a subsequent attack of the more ordinary form of measles.

*Diagnosis.*—The diseases with which measles may be confounded are scarlet fever and some forms of syphilitic eruptions. The diagnostic symptoms between measles and scarlet fever are numerous, for there are many differences both in their general laws and particular symptoms by which they may readily be distinguished. Thus, the periods of the latency of their poisons are different, that of scarlet fever being from two to ten days, while that of the measles is from ten to fourteen days. The exanthema in scarlet fever seldom appears later than the second day of the primary fever; in the measles it is delayed till the fourth day. In scarlatina the patches of the exanthema are large, and the surface they cover ample; but in measles they are not larger than flea-bites, and when most confluent the clusters are small. Their colour is also different, being of a bright red in scarlet fever, while in measles it partakes more of a raspberry hue. The affections of the mucous membranes are also different in the two diseases. In scarlatina the tonsils are almost constantly greatly enlarged and ulcerated, while in measles they are little or not at all affected. In scarlatina the eyes are free from coryza, while in measles that is the most prominent symptom. The tertiary actions of the poison are also different, being, in scarlatina, inflammatory affections of the joints, and dropsy; while in measles they are inflammations of the lungs or pleura; and, lastly, in measles the fever usually subsides on the disappearance of the eruption; but in scarlatina the fever often continues many days or weeks after the eruption has run its course, or till the sore throat has healed.

*Prognosis.*—The mortality from measles greatly varies in different years. Percival says, that out of 3807 cases of measles, 91 died, or 1 in 40. Watson says, that in one year, at the London Foundling Hospital, 1 in 10 died; and in another, 1 in 3. In the same establishment also in 1794, out of 28 cases none died; in 1793, out of 69 cases 6 died; in 1800, out of 66, 4 died; and the aggregate of these data will give as an average of 1 death in 15: so that the prognosis in every case of measles is favourable. The prognosis, however, is more favourable in the country than in the metropolis; for it appears by the registrar-general's report, that in the year 1839, the proportion per cent. of the population that died of measles in London was as ·107; while, in England and Wales, it amounted to no more than ·071.

*Treatment.*—The measles differ from scarlet fever not only in the fever being much less depressing, but in their running a shorter or more definite course, and in their having no tendency to terminate in ulceration or mortification. The measles, therefore, though depending on a morbid poison, approximate to the phlegmasiæ compared with scarlet fever, for the constitution is little impaired by the short continuance of the disease, and consequently they admit of a more strictly antiphlogistic treatment.

As no antidote is known to the poison of the measles, the disease will run its course whatever treatment we adopt. The rule of treatment, therefore, is to interfere as little as possible as long as the disease is safe, and merely to moderate symptoms when they threaten danger, and to subdue them, if possible, when danger really appears.

The *morbilli sine catarrho* are usually so mild a form of disease as to require no other treatment than a milk diet and the customary attention to the bowels. In the *morbilli mitiores*, however, the cough, the frequent vomiting, and the heavy catarrhal symptoms which so generally attend the primary fever, render medical attendance necessary from the first moment of the attack. The treatment of these symptoms, however, and also of the eruptive stage, as long as the patient continues free from any serious inflammatory affection of the lungs, need not necessarily be active, it being sufficient to alleviate the cough, allay the vomiting, and check the catarrh by some of the large class of neutral salts which afford so many useful remedies. In making our selection from these we must be principally guided by the state of the bowels and the condition of the stomach. If the bowels be constipated, the milder purging salts, as the sulphate of magnesia or the sulphate of soda in ℥ ſs. or ʒ j. doses ex. mist. camphoræ 6^tis vel 4^tis horis are to be preferred. On the contrary, if the patient be purged, and the vomiting distressing, the mist. potassæ citratis effervescens is the most beneficial. There are many persons in whom the cough and catarrhal symptoms are the most urgent, and in such cases, if the stomach be quiet, the liquor ammo-

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niæ acetatis in ʒ ſs. doses ex. mist. camphoræ, from its more powerful action on the skin, is an excellent substitute. Another remedy equally or perhaps still more useful, is ipecacuanha, of which, gr. j. vel gr. ij., may be given 6tis vel 4tis horis. Some practitioners prefer antimony to ipecacuanha, but antimony appears, at least in large doses, to act in some instances perniciously on the lung.

The treatment which has been specified is, in many cases, all that is necessary throughout the whole course of the disease; and the greatly extended experience of Willan has hardly enabled him to enlarge it. He thinks, however, that an emetic given on the second or third evening *somewhat* alleviates the violence of the catarrhal symptoms, and contributes to prevent the diarrhœa which usually succeeds the measles. During the eruption, he adds, "I have not observed any considerable effect from antimonials or other diaphoretics." Bathing the feet every evening seems a more beneficial application. Emulsions and mucilages afford but a feeble palliation of the cough and difficulty of breathing. With respect to opiates, Sydenham gave an opiate every night throughout the whole course of measles; but in the early stages, according to Willan, it produces an increase of heat and restlessness without conciliating sleep.

The catarrhal symptoms are frequently accompanied, even in the very earliest days of the disease, with much bronchial inflammation, and sometimes with pneumonia; or these affections may occur at any later period after the decline of the eruption, or from the tenth to the twelfth day of the attack. This great tendency to pneumonia has caused the question to be agitated, whether bleeding ought not to be adopted as part of the treatment of this disease in all cases, either as a means of cure or as a precautionary measure, or whether it should be reserved until the pneumonic symptoms are present. Experience has shown that bleeding may be practised with impunity in the very first onset of the disease, or at any subsequent stage. Willan, however, is of opinion that it is very rarely necessary to bleed before the subsidence of the eruption; for, if we wait that event, we "usually find the pulse become moderate, and the uneasy, laborious respiration terminate in 24 hours. This oppressed breathing is common to other eruptive fevers; and if it were universally to be considered an indication for bleeding, the practice would often be more fatal than the disease." If, however, pneumonia or pleurisy be clearly established, blood should be freely, but not extravagantly, taken; for it should be remembered that although some children bear the loss of blood well, yet that others are long in recovering from it even when the quantity drawn is small. In children, then, below 10 years of age it is more prudent to take blood frequently and in small quantities than in a large quantity at once. We should likewise be content with moderating the symptoms, for, as the inflammation depends on a morbid poison, it has a course to run, and does not admit of a sudden cure. The bleeding should also be more moderate during the eruption than after it; for we have a right to look for a diminution of all the symptoms when it disappears. Blisters, ipecacuanha, and mercury, are amongst the best adjuvantia to bleeding in these cases.

During the whole course of the disease it is necessary to enjoin an abstinence from all animal food, and to limit the patient to a low diet and to slops. The chamber should be of a moderate temperature, and not subject to any sudden change from heat to cold, and the strictest cleanliness should be observed. In large establishments separation is necessary to prevent their spreading.

### Of the Small-pox or Variolæ.

The small-pox consists of a remittent fever, of an eruption which runs a given course, and of certain occasional tertiary affections. This poison has the property of exhausting the susceptibility of the constitution to its future action on the first attack. In the year 1839 there died of this disease, in England and Wales, 9131 persons.

Since the first appearance of the small-pox at Mecca, two great epochs have occurred in its history. The first is the discovery of the singular and beneficent law, that the destructive agency of this poison is greatly mitigated by introducing it into the system by means of the cutaneous instead of the mucous tissues, or of *inoculation*; and, secondly, the still more wonderful fact, that the vaccine poison, though differing in many of its laws from the variolous poison, has the extraordinary and unlooked-for property of protecting the constitution, and rendering it altogether insusceptible to the action of that deleterious agent.

*Remote Cause.*—The same obscurity hangs over the remote cause of small-pox as over those of measles and of scarlatina. While, however, the causes of these two latter diseases seem still active, there is every probability that of small-pox has subsided, and that this disease has now no other source than human contagion. It is singular, however, if depending on human contagion, it should still occasionally assume an epidemic character—a circumstance, perhaps, owing to the gradual accumulation of susceptible unprotected persons. In whatever manner this poison is produced, season does not appear greatly to influence its ravages; for according to the registrar-general's report, there died in 1840, in the winter quarter, 2071 cases; in the spring quarter, 2476; in the summer quarter, 2274; and in the autumnal quarter, 3613.

*Predisposing Causes.*—There are so few persons susceptible of the poison who escape infection, when exposed to its influence, that the subject of predisposing causes has not been much studied. There are circumstances, however, not easily appreciable which do predispose to this disease; for example, a gentleman long accustomed to frequent the small-pox hospital, and even to make drawings from the deceased with impunity, at length took the disease from being accidentally in the same room with a variolated corpse. A nurse, also long attached to that hospital, and in constant attendance on the small-pox patients, went into the country for a short recreation; but on her return she became infected, and passed through the disease. This susceptibility or insusceptibility to the poison depends partly on the constitution and partly on accidental circumstances. Mr. Hunter states he inoculated a number of slaves off the coast of Africa, and that those that took the disease before the Harmattan all did well, but such as were not seized with the symptoms when that wind began to blow, and they were sixty in number, never felt any other than a slight nausea and fever during the continuance of the wind. After, however, it had changed, the small-pox appeared in twenty, but

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the others were obliged to be re-inoculated, when they all did well.

Both sexes and all periods of life are equally liable to this affection. The ages, however, at which persons are attacked, as deduced from the ages at which they have died, of the small-pox, are as follows:—

Deaths of Males and Females from Small-pox.

| Months Old. | Died. | Years Old. | Died. | Years Old. | Died. | Years Old. | Died. | Years Old. | Died. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 202 | 0 | 2,235 | 10 | 226 | 40 | 43 | 75 | 4 |
| 1 | 181 | 1 | 1,524 | 15 | 226 | 45 | 22 | 80 | 10 |
| 2 | 162 | 2 | 1,197 | 20 | 240 | 50 | 13 | 85 | 1 |
| 3 | 456 | 3 | 869 | 25 | 148 | 55 | 10 | 90 | 0 |
| 6 | 646 | 4 | 628 | 30 | 93 | 60 | 19 | 95 | 1 |
| 9 | 588 | 5 | 1,122 | 35 | 75 | 70 | 10 | Unknown | 8 |

The small-pox once engendered, the person of the patient generates a poison which is both *infectious* and *contagious*.

*Infectious*.—This disease is so infectious, that not only is it unsafe for a susceptible person to be in the same room, or in the same house, with a party labouring under the disease, but it has often been caught by passing a child in the small-pox in the street, and even on the other side of the way; so that "to expose a person in the public highway, infected with this contagion, is considered a common nuisance, and indictable as such." The dead body of a variolated person is equally infectious, and students, who have merely seen it when brought into the dissecting-room, have in consequence fallen ill of the disease. The *infecting distance*, therefore, must be many yards around the patient's person: indeed, with every precaution, there is great difficulty in preventing it spreading from ward to ward, even in large hospitals.

*Contagious*.—The fact of the contagious nature of small-pox has been fully demonstrated by the once general practice of inoculation; and the poison by this operation has been proved to exist in the serum, in the pus, and in the crusts of the small-pox pustule. There is no law more singular and unexpected, in the whole range of morbid poisons, than that the introduction of the variolous poison, by means of the cutaneous tissue, should produce an infinitely milder disease than when the same poison is absorbed by a mucous tissue. It appears essential, also, that it should pass *through* the skin; for when the puncture has been made deep, so as to see "a bit of fat," the disease which has ensued has hardly been mitigated. The contagion, per

*Fomites*, besides being shown by the practice of inoculation, has been demonstrated by the disease spreading almost all over the continents of Africa and of America, by the transmission of an infected blanket, or other article of clothing. One lady caught it by putting on a shawl worn by her friend, who had just fallen ill of the disease. Dr. Gregory mentions the wife of a registrar-general, with whom he was sitting, taking the disease from a nurse who came to announce the death of a parishioner by the small-pox, the contagion being brought, as is supposed, in the woman's clothes.

The length of time fomites may remain infected may be seen from the fact of the Hindoos seldom inoculating but with matter a twelvemonth old.

*Susceptibility exhausted*.—The small-pox has the property, in common with measles and scarlet fever, of exhausting, on the first attack, the susceptibility of the constitution to the future actions of the poison. This law, however, is not without some exceptions, and in the late epidemic at Marseilles, Bousquet considered one person in one hundred was attacked a second time with small-pox. In some few instances even a second attack has no protective influence. Dr. Roupel says he met with an instance in which small-pox occurred three times in the same person. The lady of a Mr. Guinnett had it five times. Dr. Maton speaks of a lady who had it seven times; while Dr. Baron mentions a surgeon of the South Gloucestershire militia, who was so susceptible that he took the small-pox every time he attended a patient labouring under that disease.

*Co-existing*.—The variolous poison is capable of *co-existing* with many other poisons, and also of influencing their actions, and of being reciprocally influenced by them. Dessessarz has seen variolæ co-exist with scarlatina and with hooping-cough; Cruikshanks with measles; Frank with psora; and Dimsdale with syphilis. A patient was admitted into St. Thomas's Hospital with tertian ague; the ague subsided and the small-pox appeared. The small-pox having run its course, the ague immediately returned. Ring mentions a case of triple disease co-existing, or of small-pox, measles, and hooping-cough, and they all ran their course together.

The reciprocal influence, however, of the variolous and the vaccine poisons over each other is among the most remarkable phenomena incident to morbid poisons; for the poisons being introduced into the system together, the one disease may precede the other, or they may co-exist. But either disease having run its course, the constitution, as a general law, is protected not only against the action of the poison that produced it, but also against the action of the other poison. Thus, a patient having had the small-pox is guarded not only against the small-pox, but also against the cow-pox; and, on the contrary, the cow-pox poison guards the constitution against the cow-pox, and also against the small-pox. There are many exceptions, however, to this law, which will be shown when treating of the vaccine disease; but still the exceptions are too few to invalidate the general principle, or to render the practice of vaccination less advisable and less practically useful.

The variolous poison, it will have been seen, may be introduced into the system either by a mucous membrane or by the cutaneous tissue, and that when introduced by the mucous tissues, it always produces a disease of great malignity and frequent fatality, or the *natural small-pox*. While, on the contrary, when introduced by the cutaneous tissue, or by *inoculation*, it almost always produces a mild disease, rarely attended by any

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fotal result. In whichever way, however, it is introduced it iofects the blood. The proof of this law is, if blood be taken from a patient labouring onder small-pox, and be injected into the veins of a dog, the animal dies, although a similar injection of healthy blood would not be attended with any inconvenience. A stronger proof, if possible, is, that many children have beeo born covered with the small-pox eruption; and it is remarkable that this pathological phenomenon has taken place, not only when the mother has been labouring onder the disease, but also when she has beeo entirely free from it. In some cases there has appeared reason to believe that the child must have gone through the disease while yet in utero; while Dr. Jenner thinks he has seen cases in which the child must have been infected in utero, and so lately that the disease has appeared withio a few hours after birth.

*Period of Latency.*—The variolous poison having infected the blood, lies in latent combination with that fluid a period of time which varies according to another remarkable law, or according as the poison has been introduced by the mucous or cutaneous tissues. Io the former case, or in natural small-pox, for example, the more usual time of latency is from ten to sixteen days, while in the inoculated small-pox the period of latency is only from seven to nine days. The extremes, taking both forms of the disease, being from five to twenty-three days. It is not yet determined at what period this poison is first geoerated by the patient's person, or whether, during the primary fever, or oot till after the eruption has appeared; but, as in measles, it is probably secreted during the primary fever.

*Pathology.*—The theory of the small-pox is, that a poison is absorbed and infects the blood, and after a given period of latency, gives rise to "primary fever," which lasts from two to four days, till the eruption appears, when it for the most part *remits*. The eruption, or secondary, or specific actioo of this poison affects the skin, and also the mucous membrane, of the eyes, nose, of the mouth, and of the fauces. It runs a given course of vari,* of vesicle, and of pustule, and when full out, or at its height, the febrile phenomena, which had remitted, return, and give rise to what is termed the *secondary fever*. The tertiary actions of the poison are inflammation of the various tissues of the lungs, affections of the urinary organs, and lastly of the cellular tissue of the body generally, which often becomes the seat of an endless number of abscesses.

The law, that fever precedes the secondary or specific actions of the poisno, or the appearance of the eruption, has scarcely ao exception, and indeed in some instances it has been of so severe a character as to have destroyed the patient on the first onset. The remission or subsidence of the fever is also constant in mild cases, but in the severer forms of the confluent small-pox it sometimes runs on, and is constant. The recurrence of the "secondary fever," and the exacerbation of the fever in severe cases at the time of the maturation of the pock, is also constant. The cause of this secondary attack has long been a difficulty in the history of small-pox, some attributing it to a remittent nature of the fever, while others consider it to result from the maturation of the pustules, and to be a *suppurative* fever. The former, however, seems the most probable explanatioo.

The second great law of small-pox, or that the secondary actions of the poison occasioo a peculiar eruption, has only a few rare exceptions, or the variolæ sine eruptione. With that exception the eruption is uniformly present; but the affection of the mucous membranes is often wanting in mild cases, though rarely absent in severe ones. The law also that the poison produces many tertiary actions, as inflammation of the lungs, of the urinary organs, of the eye, and of the cellular tissue, is generally admitted. These actions, however, are often wanting in mild cases, and it is to be regretted that the proportionate frequency of their occurrence is not determined.

The small-pox pustule, which is the great characteristic of the disease, runs a given course of about eleven days, and in its progress uodergoes many mutations, being at first tubercular, then vesicular, then pustular, and lastly it forms the scab or crust. These various chaoges form so many stadia of unequal duration. The first, or tubercular stage, lasts from twenty-four to forty-eight hours; the second, or vesicular stage, four days; the pustular stage three days; while the last stage, or that of scabbing, lasts three days more, making the whole duration of the *normal* pustule ten or eleven days. There are varieties, however, of this disease, in which the formation of the pustule is irregular, as io the *confluent* and *horn* small-pox, and in the latter the two last stages are singularly shortened, or else absent altogether.

The distinct small-pox, then, consists, oo the first appearance of the eruption, of a number of soall red tubercula or vari, about the size of a pin's head, more or less numerous, but separate and distioct from one another, and scarcely salient. On the second or third day the second stage commences, and a small vesicle, which gradually enlarges, bound down and depressed in the centre, or *umbilicated*, forms on the apex of each varus, and contains a clear whey-coloured fluid. This stage lasts about four days, when the pustule maturates. This process is so gradual, that Dr. Watson says, if you examine the pustule closely about the fifth or sixth day you may see, at least in maoy, two colours, viz. a central whitish disk of lymph, set in, or surrounded by, a circle of yellowish puriform matter. "In truth, there is in the centre a vesicle, which is distinct from the pus, so that you may puncture the vesicular portion, and empty its contents without letting out aoy of the pus, or you may puncture the part containing the pus and let that out without evacuating the conteots of the vesicle." While this change also is going on, a damask red areola forms around each pustule, and as the vesicle fills the whole face swells, and often to so great a degree, that the eyelids are closed. When the maturation is complete the "*bride*," which bound down the centre of the vesicle, ruptures, and the pustule now becomes spheroidal or *acuminated*. About the eighth day of the eruption a dark spot is seen on the top of each pustule, and at that spot the cuticle ruptures, and allows a matter to exude, which concretes into a scab or crust, and during this process the pustule shrivels and dries up. This crust is detached betweeo the eleventh and fourteenth days, leaving the cutis beneath of a dark reddish brown, a discoloratioo which lasts many days or weeks. On the face, however, the pustule often penetrates or burrows, so as to cause ulceration of the rete mucosum, and to leave a permanent depression or "pit," greatly disfiguring the person. The cicatrix formed on filling up of these ulcers, though at first of a reddish-brown, is ultimately a dead white colour.

The small-pox eruption does not appear over the

* Varus, a small tumor.

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whole body at once, but, like the other exanthemata, appears in three successive crops. The first crop covers the face, neck, and upper extremities, the second the trunk, while the third appears on the lower extremities. There is usually an interval of several hours between each crop, and by how much the later the pustules are in appearing on the trunk and lower extremities than on the face and neck, by so much the later they are in maturating and in disappearing from those parts.

The number of pustules is very various, sometimes not exceeding five or six over the whole body, more commonly from one to three hundred, and occasionally amounting to several thousands. It has been calculated, if ten thousand pustules be counted on the body, that two thousand at least will be found on the face, and accordingly the number of pustules on the face being in proportion those on the other parts of the body, is a fair estimate of the extent of the disease, and of the danger of the patient.

The pustule is subject to many irregularities, both as to its form and course, and which give rise to two very marked varieties of the disease, or to the confluent and to the horn small-pox. The confluent small-pox differs from the distinct small-pox in the tubercula or vari being small, less prominent, and so numerous that even on the first appearance of the eruption there is hardly any distinct separation between them. The vesicles which form on their apices appear earlier, and their diameters increase more irregularly than in the distinct forms, and often they run one into the other. The pustules likewise, which are confluent, either remain flat and do not rise, or else, the cellular tissue rupturing, they form large bullæ or bladders, (variolæ corymbosæ) and are not encircled with the usual red areola round their base; neither do their fluid contents always acquire the yellow colour and thick purulent consistency of the milder disease. Their crusts, moreover, are soft, and do not fall off till many days after the usual period, or not till the eighteenth or twentieth day, or even later; and when the desiccation is completed and the crust detached, a deep scar or pit, sometimes an extensive seam, shows the destructive ulceration that has taken place beneath them.

The horn small-pox is a variety of the distinct small-pox, and is by much the mildest form of the disease. The pustule in this variety passes through the stages of vari and of vesicle, but on the fifth or sixth day of the eruption, instead of maturating, the pustule shrivels, desiccates and crusts, and the disease terminates three or more days earlier than the usual course, and without the occurrence of any secondary fever. This is the form of the disease which so usually follows after vaccination.

Many other varieties have been described by the old masters: Sydenham, for instance, speaks of a black small-pox; Mead, of a blood small-pox; Friend, of a siliquous small-pox, in which the pustule resembles a small hollow bladder, but contains no fluid. These varieties of the pustule were probably occasioned by improper treatment, or by some rare idiosyncrasy of temperament, and are consequently not mentioned by modern writers. There is one variety, however, which is not uncommon, which is the crystalline or pearl pock (*variolæ crystallinæ*), in which the vesicle continues transparent, seldom maturates, and has a tendency to become confluent. Every variety of the eruption, also, when the disease is severe, may be intermixed with petechiæ.

The cutis is more particularly the seat of the variolous eruption; but let the affection be at all severe, the mucous membrane of the conjunctiva, of the palpebræ, of the nasal fossæ, of the mouth, and of the pharynx, are covered with it. The variolous poison consequently produces an eruption on two classes of membranes, or on the skin, and on the buccal and facial mucous membrane. It has been much disputed whether the eruption forms on any other of the mucous membranes, and as a general principle it does not; but Martinet found, in a man that died on the eighth day, the rectum covered with variolous pustules. Rostan has seen the alimentary canal garnished with pustules similar to those of the mouth, from the œsophagus to the rectum. Sir Gilbert Blane also met with pustules on the mucous membrane of the intestines in two cases that died in the West Indies: and Rayer has given a plate representing pustules on the mucous membrane of the trachea. Dr. Mead's experience has made him state that, "I myself have seen subjects in which the lungs, brain, liver, and intestines were thick beset with pustules." Dr. Pitzholdt, in the morbid anatomy of small-pox, says he has seen the peritoneum covering the liver and the spleen, presenting appearances which he felt justified in regarding as the product of the small-pox.

The pustules which form on the mucous membranes have not been very distinctly studied either as to their course or phenomena. Rayer terms them *rudimentary* pustules; they probably, however, undergo the usual mutations of vari, of vesicle, and perhaps of pustule; but their course is shorter than when they occur on the skin; neither do they crust, although they sometimes run into ulceration.

Salivation is a common symptom in small-pox; but whether the salivary glands are affected in consequence of an extension of this inflammation, or from a tertiary action of the poison, is not determined. The small-pox having been chiefly studied previous to any sound knowledge of morbid anatomy, or of the laws of morbid poisons, its tertiary actions are as yet but imperfectly known; but about the eighth day in the distinct, and the eleventh day in the confluent small-pox, a secondary fever is established, and at the same time a new series of phenomena present themselves in a few severe cases,—as affections of the lungs, of the urinary organs, or of the cellular tissue of the body generally.

The most frequent affection of the lung is hæmoptysis, but occasionally inflammation of those organs takes place. The mucous membrane, for instance, of the trachea is found often covered with a thick semi-purulent muciform matter, peculiar to small-pox, irregular or honey-combed at its free surface, and which being removed, the subjacent tissue is found diffusely inflamed. The substance of the lungs also is occasionally found inflamed in every degree, even to purulent infiltration. The pleura also, according to Dr. Gregory, is peculiarly disposed to inflammation, which comes on about the eleventh or twelfth day, for the most part very suddenly, proceeds rapidly to empyema, sometimes destroying the patient in thirty-six hours. The pleura does not merely run into suppuration, but takes every other form of inflammation to which it is at any time liable.

The tertiary action of the variolous poison on the urinary organs and on the uterus is seen in the frequent occurrence of hæmaturia, and in the occasional formation of abscess of the kidney; while its action on the uterus is manifest from menorrhagia in the unimpreg-

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nated state, and also of frequent miscarriage when the patient is parturient.

The cellular tissue of the body generally is also acted upon by this poison. In two cases examined a few hours after death, the bodies could with difficulty be laid on the table, the skin being detached by the pressure necessary to raise them; the serous coat of the intestines also separated from the mucous and muscular coats with the greatest facility for many feet, and apparently could have been entirely peeled off. In one of these cases, also, the finger could be thrust through the walls of the heart with ease, as if the muscles of that organ had become unnatural, soft, and broken down. This affection of the cellular tissue generally also is seen in the great tendency in some cases to the formation of abscess on the subsidence of the eruption; for 20, 30, and even more small abscesses will sometimes form on a limb or other part of the body in most formidable succession, and which, being opened, are found to contain a sanies, or, only in a few instances, laudable pus.

The different lesions that have been mentioned are not the only miseries from which the patient may suffer; for these are often followed by sequelæ even more formidable than the preceding phenomena, as blindness, deafness, or lameness. With respect to blindness, it is generally supposed that pustules form on the conjunctiva or cornea, the inflammation then extending to the deeper-seated parts, and thus destroying the eye. Mr. Marson, however, surgeon to the Small-pox Hospital, says that, according to his experience, "the eye seems to possess a complete immunity from the small-pox eruption, and that although it sometimes extends to the inner margins of the eyelids, the particular local affection that causes the destruction of the organ of vision in variola begins generally on the 11th or 12th day, or later, from the first appearance of the eruption, and when the pustules in every other part of the body are subsiding. It comes on after the secondary fever has commenced, with redness and slight pain in the part affected, and very soon an ulcer is formed, having its seat almost invariably at the margin of the cornea. This continues to spread with more or less rapidity, and the ulceration passes through the different layers of the cornea, until the aqueous humour escapes, or till the iris protrudes. In the worst cases there is usually hypopion, and when the matter is discharged the crystalline lens and vitreous humour escape. In some instances the ulceration proceeds very rapidly; I have more than once seen the entire cornea swept away within 48 hours from the apparent commencement of the ulceration; and what is singular, now and then the mischief goes on without the least pain to the patient, or his being aware that anything is amiss with his eyes." This gentleman calculates that in 1000 cases 26 had ophthalmia, or about 1 in 39, and of these 11 lost an eye each, or 1 in about 100.

The inflammation of the buccal membrane may extend to the Eustachian tube, causing suppuration of the ear, and sometimes permanent deafness. It may spread also to the glottis; and the patient has been known to die suffocated by effusion into the cellular tissue around it, causing occlusion of the aperture. Sometimes it has terminated in ulceration, with the loss of a portion of the nose, or in a caries of the jaw-bone, or in enlargement of the glands of the neck.

Such are the pathological phenomena of the small-pox. Death, however, according to the experience of Jenner, Mead, Maitland, and others, has not unfrequently anticipated their action, and destroyed the patient during the primary fever, and before any of them could be set up.

*Symptoms.*—The species of small-pox are the natural small-pox, the inoculated small-pox, and the small-pox after vaccination. Of the natural small-pox there are three varieties, or the variolæ sine eruptione, the variolæ discretæ, and the variolæ confluentes.

*Symptoms of the variolæ sine eruptione.*—Sydenham and Frank have observed in every variolous epidemic, that some few persons who have not previously had the small-pox, or, according to Frank, have neither had the small-pox nor been vaccinated, are seized, during the time the small-pox is raging, with all the symptoms of primary variolous fever, and which having subsided, they have afterwards been found insusceptible of the disease. Sydenham states that he has seen fatal cases of this kind attended with purple spots and bloody urine; and hence the variolæ sine eruptione.

*Symptoms of the variolæ discretæ.*—Of the variolæ discretæ there are two varieties, or the variolæ discretæ, and the variolæ discretæ verrucosæ.

The symptoms of variolæ discretæ, or of distinct small-pox, may be divided into three stages. The first stage comprises the primary fever, which commences with the disease and terminates with the appearance of the eruption. The second stage commences with the eruption and terminates with the appearance of the secondary fever. The last stage commences with the secondary fever, and includes all the subsequent phenomena.

In the adult the symptoms of the first stage are not to be distinguished from those of the first stage of typhus; but in children there is a greater tendency to vomiting, and the brain also is more oppressed with drowsiness, stupor, or coma, and followed occasionally by convulsions. Sydenham says, when children, especially after dentition, are seized with convulsions during the primary fever, it is a sign the eruption will shortly appear. The ordinary duration of this fever is four days, and it may be sudden in its attack, or be preceded by some days' illness, in which case the most prominent symptoms often are severe muscular pains similating rheumatism.

On the fourth day inclusive from the first attack of the primary fever, sometimes sooner, and but seldom later, the eruption appears, and the second stage commences. The phenomena of the second stage are as a calm succeeding to a storm; for, on the appearance of the eruption, the fever remits, the heat abates, the affection of the head subsides, the vomiting ceases, and the pulse returns to its natural standard, and consequently the febrile phenomena have altogether disappeared.

The number of pustules varies, according to the severity of the case, from 20 to some thousands. They appear, as has been stated, in a succession of crops, or first on the face, neck, and upper extremities; then on the trunk, and lastly on the lower extremities, and run the course, and undergo the various mutations of varus, vesicle, and of pustule already described. About the eighth day of the disease, however, or when the eruption is fullest out over the whole body, and the pustules of the face begin to maturate, the whole face, head, and neck swell, particularly the eyelids, which often close and blind the patient; the swollen parts also throb and are painful when touched. The intumescence of these parts lasts three days, during which the spaces between



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the pustules inflame, and are of a deep red or damask-rose colour, and the closer this resemblance the milder the subsequent affections.

It is during this period of intumescence that the fever which had remitted returns, and the third stage, or that of secondary fever, commences. This attack, in cases of ordinary intensity, is marked by a considerable increase of heat, by a frequent pulse, and by slight delirium, from which the patient is easily aroused. If, however, the disease be of greater intensity, hæmaturia, hæmoptysis, or a hard dry cough are added. In favourable cases, the swelling of the face, the redness of the intervening spaces, and also this secondary fever, having lasted from the eighth to the eleventh day, subside, and the pustule, now fully ripe, bursts and discharges a thin yellow matter, which, concreting into a crust, falls off on the fourteenth or fifteenth day, and the disease terminates.

When, however, the disease assumes an unfavourable character, and threatens a fatal termination, the face, which ought to have been intumescent on the eighth day, remains without increase of size, and the spaces which ought to have inflamed are pale and white. The pustules also, says Sydenham, look red and continue elevated, even after death, and the sweat, which flowed freely up to this day, suddenly ceases. At this critical period the secondary fever, instead of its usual sthenic character, may assume one of two forms, or that of the second stage of typhus, with brown tongue, frequent pulse, and delirium, or else the patient may be overwhelmed with the depressing influence of the poison, and sink almost without experiencing a re-action, the pulse being hardly increased in frequency, the heat of the body natural, and the intellect unimpaired. But the patient suffers from an indescribable restlessness, an inexplicable anxiety, some cough, with sickness, a frequent desire to pass urine, and with these symptoms he dies after a short struggle.

In cases of any degree of severity, even in the variolæ discretæ, the poison acts not only on the skin but also on the buccal and ocular membrane, and produces an eruption of pustules on those parts. This additional affection, however, does not appear to aggravate the fever, or to occasion other inconvenience than what arises from the local disease. The buccal eruption is usually preceded and accompanied by soreness of the throat and difficulty of swallowing; but these symptoms do not exceed those of a common sore throat. The pustules also, which form within the eyelids, are not attended with much pain, and it is only when the swelling has subsided that the mischief which sometimes takes place is discovered.

*Symptoms of the variolæ discretæ verrucosæ, or horn small-pox.*—The symptoms of this variety are similar, but milder than those of the preceding disease, for the primary fever is little more than a febricula; the pustules do not exceed half a dozen to two or three hundred, and having passed through the stages of varus end of vesicle, they on the eighth day, or about the usual time of maturation, shrivel, desiccate, and crust. The secondary fever also, often so fatal, does not recur, so that the convalescence usually commences on the eighth day, and the disease is terminated on the eleventh.

*Symptoms of the variolæ confluentes.*—The confluent small-pox is described by Sydenham as beginning with symptoms similar to those of the distinct small-pox, but more violent. The first stage, or primary fever, being attended with more sickness and vomiting, with greater heat, with more severe muscular pain, with more considerable delirium, end in children often on the evening before the eruption by convulsions. This fever is not only more intense than in the distinct kind, but is also of shorter duration, the eruption appearing more generally on the third day, or even earlier; and by how much the sooner the pustules appear, by so much the more confluent is the disease that follows. The eruption is often preceded also by an extensive erythematous or erysipelatous inflammation, and the vari come out irregularly, or in small clusters, like the measles, and are less eminent than in the distinct small-pox.

When the second, or eruptive stage, is formed, the primary fever remits, but not so completely as in the distinct kind, for the pulse often continues frequent (110 to 120 in a minute), the tongue white, and even the delirium may recur in the evening. This eruption also has some remarkable characters, for the pustules, especially those of the face, do not rise, they are more irregular and flatter in their forms, and from their greater number and contiguity run into each other, or are confluent, sometimes forming bullæ as large as a hen's egg.

Another symptom also sometimes seen in the distinct, never fails to accompany the second stage of confluent small-pox, or *salivation*. The salivary discharge begins either with the eruption or within a day or two after, and is then thin and copious, resembling the ptyalism by mercury. About the eighth day, however, it becomes viscid, and is expectorated with difficulty; while in bad cases it either ceases for a day or two and then returns, or else it disappears altogether. Children are not so liable to this salivation as the adult, but in them a vicarious diarrhœa often appears, but not constantly, neither does it occur so early in the disease. It is frequently profuse, unless checked, and often proceeds till the disease terminates.

It has been stated, that on the appearance of the eruption and the commencement of the second stage, although the fever is mitigated, it does not altogether subside, but that the affection of the head, the frequency of the pulse, and greater heat of the surface, often continue. With these ominous symptoms then still present, on the eighth day of the eruption, or the 11th day of the fever, the third stage, or secondary fever, commences, bringing with it new sources of anxiety to the physician and of danger to the patient.

"The confluent small-pox," says Sydenham, "does not in the least endanger life in the first days of the illness, unless there happens a flux of blood from the urinary passages, or from the lungs. Yet, on the decline of the disease, or on the 11th, 14th, 17th, or 21st days the patient is often brought to such a state that whether he will live or die is equally uncertain. He is first endangered on the 11th day by a high fever, attended with great restlessness and other symptoms, which ordinarily prove destructive, unless prevented by medicine. But should the patient outlive this day, the 14th and 17th are to be apprehended, for a very vehement fit of restlessness comes on every day towards evening, and there is the greatest difficulty in saving him.

The fatal symptoms of the third stage are, the absence of the usual redness in the intermediate spaces, the non-intumescence of the face, the suppressed salivation, cough, with hæmoptoë, or hæmaturia, and great restlessness. Sometimes other symptoms are added to these, as a brown tongue, delirium, petechiæ, or a black

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spot in the centre of each pock, scarcely so big as a pin's head, or else a disposition to gangrene in the large vesicles; and when these symptoms are present few persons survive this terrible crisis. In some cases, however, the event is favourable, and the patient is restored, hut the struggle is sharp and the convalescence long, end in its progress an endless series of abscess may form, or inflammation of e joint take place and produce lameness, ulceration of the cornea, blindness, otitis or deafness, while the deeply-scarred face is e lasting record of the severity of the disease, and of the great danger the patient has survived.

*Symptoms of Variolæ post Vaccinationem*.—The symptoms of this form of the disease are in the great majority of cases those of the variolæ discretæ verrucosæ. In a few instances, however, they are those of the distinct end still more rarely those of the confluent small-pox; but whatever form they may assume their *comparative* mildness is their great characteristic.

*Symptoms of Variolæ post Inoculationem*.—The phenomena which result from the introduction of the variolous poison by means of the cutis differ in many respects from those that occur in tha natural small-pox, and they ere as follows:—On the day efter the operation is performed, though it take effect, little alteration is discovered in the punctured part. On the second day, however, if the part be viewed with a lens, there generally appears an orange-coloured stain around the incision, while on the 4th or 5th day the pert is hard, slightly inflamed, and itches, end e vesicle containing serum is formed on it. About the 6th day some pains and stiffness are felt in the axilla, symptoms which foretell the near approach of the fever and the favourable progress of the disease. On the 7th day the vesicle becomes more developed, and the red areola forms round its base.

The operation having now been performed seven, eight, or nine days, the usual period of latency of the poison, and the vesicle having existed four days, the ordinary symptoms of primary fever appear. This fever lasts three or four days, when the general eruption follows, now called the secondary eruption, the pustules coming out, as usual, in three successive crops, or on the face, trunk, and lower extremities. On the day of the general eruption the primary pustule, says Dr. Gregory, is distended with matter, and so proceeds on its course that it has scabbed when the secondary eruption is only about to maturate.

The most remarkable laws, however, of the inoculated small-pox are the singuler mildness of the fever and the diminished number of the pustules of the secondary eruption. The mildness of the fever is thus instanced by the late Dr. Watson, of the London Foundling Hospital: "Of the seventy-four persons whose histories I have related, though inoculated with variolous matter in different states, although prepared in so different n manner, and e great number not otherwise prepared than by an abstinence from animal food, not one of them were disordered enough during the whole progress to occasion the least anxiety for the event; not one them had, from the pustules being upon the eye or near them, their eyes closed a single dey; none continued in bed an hour longer than they would have done in their best health."

The number of pustules is subject to great verieties, but, with very few exceptions, it is much less than in the natural small-pox. In some cases not more than two or three appear, occasionally only the primary pustule is seen; but more generally the number varies from ten to two hundred, the mean being thirty or forty. Such is the general course of the inoculated small-pox. In a few instences, however, the disease that follows this operation is extremely severe, and in a still smaller number it is confluent; and in either case the patient is perhaps destroyed. Many theories have been invented to explain the singular mildness of the inoculated small-pox, but none of them are satisfactory.

*Diagnosis*.—It is not possible to distinguish the primary fever of small-pox from that incident to the other exanthemata, or from the first stage of continued fever. In the adult, however, the muscular pains are more severe, and in children there is a more frequent occurrence of convulsions.

The small-pox eruption, on its first eppearance, is with difficulty distinguished from the varicellæ; but after a few hours its characters are so strongly marked that nobody who has seen the two diseases can confound them.

*Prognosis*.—The prognosis of the natural small-pox is always most grave. The calculation of the proportionate number of deaths, however, eppears to have greatly veried in different years. It was formerly supposed that one in five or six ettacked perished. In the present day, when the adult is almost its only victim, the records of the Small-Pox Hospital show that the loss has averaged thirty per cent., the extremes in different years being eighteen and forty-one per cent. In the epidemic of 1838,—

Of Unprotected.

| | Admissions | Deaths. |
|---|---|---|
| Of Confluent Small-pox . . | 295 | 149 |
| Semi-confluent . . . . | 78 | 8 |
| Distinct . . . . . . | 19 | 0 |
| Total . . | 392 | 157 |

Of Vaccinated.

| | Admissions | Deaths. |
|---|---|---|
| Of Confluent Small-pox . . | 56 | 21 |
| Semi-confluent . . . . | 42 | 4 |
| Distinct . . . . . . | 20 | 0 |
| Total . . | 118 | 25 |

Sydenham considered the eighth, eleventh, fourteenth, and seventeenth deys were the most fatal. Dr. Gregory has given us the number of deaths that took place on each day of the eruption; in 168 fatal cases,—

| First Week. | Deaths. | Second Week. | Deaths. |
|---|---|---|---|
| 3rd Day . . | 1 | 8th Day . . | 27 |
| 4th ,, . . | 5 | 9th ,, . . | 15 |
| 5th ,, . . | 10 | 10th ,, . . | 14 |
| 6th ,, . . | 5 | 11th ,, . . | 16 |
| 7th ,, . . | 11 | 12th ,, . . | 11 |
| | | 13th ,, . . | 11 |
| Total . | 32 | 14th ,, . . | 5 |
| | | Total . | 99 |



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| Third Week. | Deaths. | Fourth Week. | Deaths. |
|---|---|---|---|
| 15th Day . . | 7 | 22nd Day . . | 3 |
| 16th ,, . . | 5 | 23rd ,, . . | 1 |
| 17th ,, . . | 3 | 24th ,, . . | 3 |
| 18th ,, . . | 3 | 25th ,, . . | 1 |
| 19th ,, . . | 1 | 27th ,, . . | 1 |
| 20th ,, . . | 2 | 28th ,, . . | 1 |
| | | Fifth Week. | |
| Total . | 21 | 29th ,, . . | 1 |
| | | 31st ,, . . | 1 |
| | | 32nd ,, . . | 1 |
| | | 35th ,, . . | 1 |
| | | 38th ,, . . | 2 |
| | | Total . | 16 |

In general about one in three die from confluent natural small-pox; one in ten of distinct natural small-pox; and one to three per cent. only of small-pox after inoculation or after vaccination.

*Treatment.*—It is admitted that no medicinal antidote exists to this poison, and consequently the rule of treatment is merely to combat adverse symptoms. As the loss in small-pox from the primary fever is extremely small, little more is necessary to be done during this stage than to keep the bowels open and to exhibit saline medicines. When convulsions occur, as they frequently do in children, Sydenham and Cullen recommend, in preference to all other treatment, a cordial and a slight opiate. In the second stage, as the fever subsides as soon as the eruption appears, and as the pulse is now quiet, and no symptom of any moment exists, there seems no reason to alter the preceding treatment.

At the commencement of the third stage, or on the eighth day in the distinct and the eleventh day in the confluent small-pox, a formidable and too often fatal crisis occurs in the establishment of the secondary fever. The treatment of this crisis, it will be seen, from the deaths from confluent small-pox at the Small-Pox Hospital having been in 1838 more than one-half of the whole number treated, must be most unsatisfactory. Some physicians have bled, some have purged, some have given wine, and others have given bark; and all have had to boast of the recovery of some patients, but the ultimate loss has been nearly the same under every practice. In general, in slight cases, the treatment of this stage may be trusted to mineral acids, as the infusion of roses with ♏ v. to ♏ x. of dilute sulphuric acid; while, in severe cases, the practice of Sydenham, still perhaps the best, should be adopted. His directions are,—"I order ten to twelve ounces of blood to be immediately taken away from that arm which has the fewest eruptions, and in which the vein therefore may be the most commodiously opened, and an opiate to be given in a large dose in the evening; and it is to be repeated morning and night from this time, and for some time oftener." The exhibition of an opiate is insisted upon in other parts of his works as an essential part of the treatment, for he says,—"It appears to me that opiates are as much indicated in the confluent small-pox as any particular remedy in any other disease, being a kind of *specific* here, as the bark in intermittent."

In the course of the disease gargles will be found very grateful to those patients whose buccal membrane is affected with the eruption. The patient also often suffers from severe pains of the legs, and this is best met by warm fomentations, or by putting the feet in warm water with or without the addition of a decoction of poppy-heads. The sequelæ of the disease, as sloughing sores, abscesses, &c., are to be treated by poultices and the ordinary rules of surgery; but, at the same time, the patient must be supported by a generous diet and by tonic medicines.

In India it is the practice to employ cold affusion throughout the disease; but Dr. Currie gives two cases in which he tried this practice, but they both died; and Rayer speaks of its aggravating the pulmonary symptoms. Other practitioners speak of enveloping the whole body in one immense cataplasm, and, it is said, with some success. Others have recommended the opening the pustules, and, by letting out the matter, thus prevent the secondary fever; but Huxham says, "a mortification is sometimes brought on" by this practice. Others have destroyed the pustule by caustic to prevent pitting, but it is generally determined that a worse cicatrix follows than if the cure were committed to nature.

The treatment of the affections of the eye is still most unsatisfactory; for the sight has been often lost when bark has been exhibited, while bleeding has not been more successful in stopping the ulcerous progress; and when we find 11 persons out of 26 have gone blind at the small-pox hospital, it is evident the local treatment of this disorder is not more advanced.

*Dietetic and General Treatment.*—The diet of the patient throughout the whole course of the disease should be strictly limited to slops, sago, arrow-root, and ripe fruits.

The chamber in which the patient lies should be cool, and freely ventilated. The bed-clothes should be light; the body-linen daily changed; and, when the disease is long, the patient's back should be often examined to prevent sloughing. The scalp likewise should be examined, and, if full of pustules, the hair should be cut off to prevent its matting.

There are no measures that can be relied on for preventing the spread of the disease; and if any susceptible person has been exposed to the infection, he ought immediately to be vaccinated; or, if vaccine matter cannot be obtained, he should be immediately inoculated, and in either case a mild disease will ensue.

### Of the Poison of the Varicella—*Chicken-Pox, Swine-Pox, the Hive-Pox.*

The varicella is a disease consisting of fever and of an eruption, which generally runs a given course of eight or ten days. The poison exhausts the susceptibility of the patient, on the first attack, to its future actions. The name of this eruption indicates that it was for a long time considered, if not variolæ, at least of the same family. It is dissimilar, however, to that affection in the mildness of its character, in the shortness in its course, and in its failing to give any protection against the small-pox. No death from the varicella is recorded by the registrar-general as occurring in England or Wales during the year 1839.

*Remote Causes.*—The origin of this poison is entirely unknown, as also whether it is of primary or secondary formation; but it is probably the latter, being principally mentioned by the writers on small-pox.

*Predisposing Causes.*—This disease is of so little moment, that its predisposing causes have not been studied. It is, however, for the most part peculiar to childhood

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and early adult age. The disease, once engendered, is both contagious and infectious.

*Infectious.*—The evidence of the infectious nature of the varicella is the same as that of the other exanthemata, or the spread of the disease in schools and families.

*Infecting Distance.*—The distance to which the poison may extend, when diffused through the atmosphere so as to induce the disease, is not determined, but it is not so infectious as the small-pox, scarlet fever, or measles, for, when it breaks out, its extension is easily controlled. The infectious spread of the varicellous miasmata is, therefore, probably inconsiderable.

*Contagious.*—The contagious nature of this disease has been frequently proved by direct inoculation; and several cases of its being communicated in this manner are given by Willan.

*Fomites.*—The propagation of the varicellæ by inoculation is a proof of the contagion *per fomitem.*

*Susceptibility exhausted.*—This disease, as a general principle, affects the system but once, and the exceptions to this law are not numerous.

*Co-exists.*—The varicella may co-exist with the cow-pox, the small-pox, and perhaps with many other morbid poisons.

*Modes of Absorption.*—The varicella being contagious and infectious, the poison is of necessity absorbed, both by the cutaneous and mucous tissues.

*Period of Latency.*—The period of latency of the poison, in two cases inoculated by Willan, was thirteen days in the one, and fourteen days in the other. In a third case, inoculated by Mr. Waehsel, the arm began to rise on the third day. The period of latency of the poison in the natural varicella is not determined, but it seems to be a law of eruptive diseases that the period is shorter when the poison is introduced by inoculation than when it is absorbed by the mucous membranes.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, and after a given period of latency gives rise to primary fever, which lasts from twenty-four to seventy-two hours, when the eruption appears and runs a course of eight or ten days. The fever is much mitigated on the appearance of the eruption, and entirely subsides with it.

The law that fever precedes the eruption is so generally received, that no exception is to be found in any writer. The febrile affection is of a mild character, and though for a few hours it may be severe, yet perhaps it never passes into a brown-tongue stage. The eruption has three stages,—that of varus, of vesicle, and of incrustation; and after the fever has lasted from twenty-four to seventy-two hours, a number of red papulæ, or vari, appear, which become vesicular, and perhaps in a few points pustular, on the first day. On the second day the vesicles are *umbilicated*, and filled with a whitish or straw-coloured lymph. On the third and fourth days they attain their greatest magnitude, when the central bride ruptures, and they become *acuminated*, and shortly after they burst and shrivel, except those which contain purulent matter, and have much inflammation around their base. The fifth day they begin to crust, and in four or five days more the crusts fall off, leaving for a time red spots on the skin, generally without, but sometimes with, a "pit" or depression. The "pit" is permanent, and the cicatrix generally whiter than the original tissue, and the patient consequently is marked or scarred.

The eruption is not at first universal over the body, but usually consists of a series of crops, which succeed each other at intervals of 24 hours, and die away in the order of their occurrence. The first crop usually appears on the breast and back, and afterwards on the face and extremities. The number of crops may be limited to two or three, while, in other cases, a new succession will appear every 24 hours for 10 or 12 days.

*Symptoms.*—Of the varicella there are three kinds, or the varicella lenticularis, the varicella coniformis, and the varicella globosa,—the first being usually termed the swine or hive-pox, and the two latter, chicken-pox. The symptoms of their varieties are similar to each other; their only differences consisting in the size and form of the vesicle, that of the varicella globosa being the largest.

The fever which precedes this eruption is often as severe as that which precedes a mild small-pox or the measles, but it generally, though not constantly, remits on the appearance of the eruption, and does not return as it ripens. Dr. Willan mentions its having been accompanied in some few cases by angina, but how far this is accidental has not been determined.

*Diagnosis.*—The varicella, of whatever kind, is distinguished from the small-pox by the shortness of the primary fever, by the rapid course of the eruption, and by the greater number of the crops.

*Prognosis.*—In all cases favourable.

*The Treatment* consists in abstaining from animal food, in adopting a milk diet, and in paying attention to the bowels.

As this disease is extremely mild, it is better perhaps not to separate the children when it breaks out in a school.

### Of Erysipelas.

Erysipelas is an inflammation of the skin, and very commonly of the cellular tissue, and is for the most part preceded or accompanied by fever. The duration of this disease is very various; it may terminate in a few hours, or it may last many weeks.

This disease is treated of by almost every writer, medical or surgical, from the time of Hippocrates; but there is no circumstance connected with its history that would justify particular mention in an elementary treatise. There died 1140 persons in England and Wales of this complaint in 1839.

*Remote Cause.*—The mystery which hangs over the origin of poisons is seen in a remarkable degree in erysipelas; for this disease is at all times sporadic, sometimes epidemic, and so far it would appear that the poison was derived from, and was constantly present, in the atmosphere. If, however, the doctrine of a spontaneous generation of a poison by the human body be tenable, it is more probably true of erysipelas than of any other disease; for it often happens that the slightest puncture, the opening of a vein, the bite of a leech, or the drawing of a blister, will produce this inflammation; and the disease thus produced has often been found dangerous and contagious, and consequently, if this poison has an atmospheric origin, slight causes often lay the patient under its influence.

*Predisposing Causes.*—The predisposing causes are age, mechanical or chemical injuries, as blows or burns; also certain articles of diet, as muscles or periwinkles, and many diseases likewise, as dropsy, typhus fever, or other debilitating cause. The effects of age in predisposing to this disease are considerable. New-born children, for instance, are occasionally subject to it, but from that period to adult age it is seldom witnessed.

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The period of life most subject to acute attacks is from 20 to 40, and to chronic attacks from 40 to old age. Both sexes suffer in nearly equal proportions.

This disease being once produced is both infectious and contagious.

*Infectious.*—The spread of erysipelas has been so frequently observed, both in the sick-room and in the wards of hospitals, that no doubt can exist of this disease being infectious, and the following are instances of it. In the year 1760, this disease spread so extensively through the wards of St. Thomas's Hospital, that a report got abroad that the plague was in the hospital. Dr. Baillie has seen it spread in St. George's Hospital, and Dr. Cullen in the hospital at Edinburgh. It has also been found to spread extensively on board ship; and Dr. Wells, Dr. Watson, and others, have given several remarkable instances of its spreading in families.

*Infecting Distance.*—The infecting distance is considerable. The wards of St. Thomas's Hospital are 28 feet wide, yet the disease has been observed to spread on the admission of a patient labouring under erysipelas from one side of the ward to the other.

*Contagious.*—Dr. Willan says, if a person be inoculated with the fluid contained in the phlyctenæ or vesicles of a genuine erysipelas, that a red painful diffused swelling and inflammation analogous to erysipelas is produced. The danger, however, attending this experiment has not allowed it to be repeated. Erysipelas also spreads by *fomites*.

*Fomites.*—In St Thomas's Hospital a ward has occasionally been obliged to be cleared out to stop the continued spread of erysipelas. In the navy the spread by fomites is so well understood, that it is even debated whether the swabbing the decks or dry-rubbing them is the best mode of disinfecting the ship, and preventing the spread of the disease. This disease also spread extensively, and for a long time, in the Birmingham Hospital, and was at last only got rid of by dry-rubbing, washing the wards appearing to promote its extension.

*Susceptibility exhausted.*—The patient having passed through this illness, has no security against future attacks of this poison, for many persons suffer repeatedly from erysipelas.

*Co-exists.*—The contagion of erysipelas is capable of co-existing with many other poisons. We continually observe erysipelas, for instance, co-existing with the primary as well as with the secondary symptoms of syphilis, and also with typhus fever. It was formerly not an unfrequent accompaniment of small-pox.

*Modes of Absorption.*—It is evident this poison, being both infectious and contagious, must be absorbed both by the mucous and cutaneous tissues, and probably infects the blood.

*Period of Latency.*—This disease has occasionally followed a few hours after exposure to the infection. Dr. Elliotson thinks five days elapsed in his own case, and Dr. Watson has given three cases in which the interval was a week. An instance occurred at St. Thomas's Hospital, in which a fortnight elapsed after its subsiding in one case and appearing in another in the same ward. It is probable, therefore, the period varies from two to fourteen days.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, and that after a given period of latency it produces generally, but not constantly, the phenomena of fever, which sometimes terminates in inflammation of the membranes of the brain. The great specific actions of the poison, however, are inflammation of the skin and subcutaneous cellular tissue, which runs an indefinite course.

The law that the poison occasions primary fever has many exceptions, especially in traumatic erysipelas from slight wounds, as leech-bites, or trifling punctures, as of a dropsical leg or scrotum. Idiopathic erysipelas is however very constantly preceded by fever, or, according to Frank, 18 times out of 20.

The law that the specific action of the poison is on the skin and cellular tissue has no exception. The affection of the cellular tissue may be trifling, but it is seldom altogether wanting.

The pathological phenomena which result from the action of the poison on the skin, are first, that the cutis is diffusely inflamed, the affected part being either of a bright scarlet or a rose-coloured tint, evanescent on pressure, but returning on that pressure being removed. This inflammation is usually of great extent, occupying very commonly the whole face, head, and neck, or a considerable portion of the trunk, or one or both lower or upper extremities. It runs a course extremely indefinite, as it may subside in a few hours, or continue for many weeks.

This inflammation of the skin may terminate by resolution, by vesication, or by gangrene. When it terminates by resolution, the rose-tint gradually changes to a deeper and more venous hue, and at length fades away, leaving the skin of its natural colour, but with the texture so impaired that desquamation follows. If the inflammation terminates in vesication, the cuticle is raised into a number of vesicles of greater or less size, and sometimes into large bullæ or bladders containing a yellowish transparent serum. The cuticle at length ruptures, the fluid is discharged, and a crust sometimes forms, which, on falling off, leaves the skin underneath either sound or else superficially ulcerated. Should the termination be by gangrene, the skin becomes livid or black, its whole texture more or less disorganized, while the bullæ or phlyctenæ which often form in these cases are filled with a bloody serum. The cutis, when examined after death, whatever may have been the form of the disease, is always found greatly thickened and infiltrated, but the redness, except in cases of gangrene, has entirely disappeared, the action of the capillary system long surviving that of the larger blood-vessels.

It is seldom that erysipelas is limited to a simple affection of the skin, for more commonly at some period of the disease the corresponding portion of the cellular tissue becomes the seat either of serous, adhesive, suppurative, or of gangrenous inflammation. When the termination is by effusion of serum, the quantity of fluid effused is generally so considerable that the head, face, or limb, is greatly and sometimes even hideously swollen; and if the part be now incised, the vessels are seen enlarged and more numerous than usual, and the cellular tissue loaded with serum, sometimes turbid and flaky. The tissue is also more easily torn than usual. This inflammation may terminate by absorption of the serum, but in a few cases ulceration follows, and in a few others gangrene.

Adhesive inflammation, or a deposit of lymph, seldom takes place in erysipelas without its being accompanied by the serous or the suppurative inflammation. When the patient, for example, has died from erysipelas of the head, much loose watery lymph is usually found in the integuments of the scalp or other affected part. The

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lymph thus thrown out, however, often becomes organized in this disease, causing a joint to be bound down, and its motions to be impaired, or an eyelid to be either inverted or everted.

Suppurative inflammation is uniformly preceded by serous inflammation, and the result may be the formation of an abscess, or what is much more common, pus may be *infiltrated* through the cellular tissue uncircumscribed by any adhesive inflammation, a circumstance improperly considered by many pathologists as pathognomic of erysipelas. The parts more usually the seat of phlegmonous circumscribed abscess are the eyelids, and the integuments covering the cheek-bones, and the pus in these cases is usually of a laudable and healthy character. In all other parts of the body the abscess is diffuse, and the inflammation being of a low type the pus is poor, and often little more than a fœtid sanies; and should the parts slough, it becomes loaded perhaps with a dirty broken-down cellular tissue, generally mixed with some loose lymph. In some instances the suppurative process extends between the muscles, causing extensive and often irreparable mischief. In the event of this inflammation terminating by gangrene, the integuments of an entire limb are sometimes detached, laying bare the muscles, a large artery, or a bone, involving the aponeuroses and tendons, and sometimes destroying the interior of a joint. Gangrene, however, does not equally take place in all parts, for it is seldom seen on the scalp, the face, or the trunk. It is the extremities, then, and more especially the leg and thigh, and also the labia and scrotum, that more particularly suffer from this affection.

The appearances found within the cranium are similar to those found in typhus fever. In a few instances the mucous membrane of the intestinal canal has been found inflamed or ulcerated, but not so frequently as to be attributable to an action of the poison.

*Symptoms.*—The symptoms of erysipelas arise out of the fever and local affection, and give rise to three degrees of intensity, or to erysipelas mitior, erysipelas gravior, and to erysipelas gangrænosum; and these may be acute or chronic.

In acute cases of erysipelas, the erysipelatous inflammation is generally preceded or accompanied by fever; and the attack may be sudden, or else ushered in by rigors, irregular flushings, muscular pains, accelerated pulse, white tongue, nausea, vomiting, and deranged bowels. These symptoms, when they do exist, last for some hours, perhaps till the end of the second night or beginning of the third day, when the fever becomes continued, and shortly afterwards the cutaneous inflammation appears, but without any remission of the fever.

The stages of erysipelatous fever are usually but not necessarily three in number. The first stage is marked by a white tongue, by headache, oftentimes by delirium, and by a pulse varying from 90 to 110; and this stage, if the disease be mild, may constitute the whole disease, the tongue not passing into the brown state. More commonly, however, the fever proceeds, and about the fourth, fifth, or sixth day the tongue becomes brown and dry, the temperature falls perhaps to the natural standard, but the pulse rises to 120 to 140; and the active delirium changing to a low muttering with subsultus, marks the formidable second stage of this dangerous disease. This stage is often extremely rapid, sometimes not lasting more than a few hours, or at most three or four days, when the third stage commences; and if the termination be favourable, the tongue begins to clean, the pulse becomes slower, the delirium subsides, and the patient rapidly recovers; or else, on the contrary, if the disease takes an adverse turn, fatal symptoms fast gather around the patient, and the catastrophe is death.

The whole duration of this fever is generally much shorter than that of typhus; so that in idiopathic erysipelas the three stages are often concluded in the space of five, six, or seven days, and it is only in a few cases prolonged to the fourteenth or twenty-first day. If, however, the local inflammation terminates in sloughing or gangrene, the patient may fall into hectic, and the disease may now last for many weeks or even months. When the local inflammation precedes the fever, as in erysipelas from dropsy, the white-tongue stage may be wanting, the tongue becoming brown in a few hours; and under these circumstances, should gangrene follow, the patient is irrecoverably lost.

The *local* symptoms vary according to the part affected, the mode of termination of the inflammation, and also according to the character and duration of the fever.

When erysipelatous inflammation affects the face, it may begin either in the skin, or else in the subjacent cellular tissue. If the cellular tissue be primarily affected, the face at the inflamed part becomes swollen, but the skin suffers no discoloration for some hours, so that it is impossible to distinguish it from an ordinary attack of swelled face. At length, however, the skin inflames, and the part is now red, hot, and painful as well as swollen, and the disease is fully formed.

At the commencement of erysipelas of the face, the attack is usually partial, and perhaps limited to the bridge of the nose, to one ear, to the lower eyelids, or to one cheek; but in severe cases it gradually extends, often involving the whole of the integuments of the face, head, and neck; so that at the end of three or four days those parts present a strangely swollen, disfigured, and even in some instances, hideous appearance, scarcely a feature being discernible. The nostril, moreover, is imperforate from internal swelling, so that the patient is obliged to breathe with his mouth open, while the inflammation may extend to the auditory passage, and render the patient completely deaf.

On the fourth, sixth, eighth, or some later day, the bright-red colour of the skin changes to a deeper hue; the serum effused is absorbed, and desquamation taking place, the skin gradually returns to its natural colour. It is not unusual, however, for abscesses to form, particularly on the eyelids or cheeks, and which being opened quickly, heal, and hardly retard the convalescence of the patient. In some cases the disease becomes *erratic*, and extends over the chest or down the back, and desquamation is seen going on in one part while the erysipelas is spreading in another.

The trunk is occasionally the seat of this disease; and in this case the febrile affection is less violent in the first stage than in inflammation of the face; but in the second stage it is often much longer and of a lower type, so that the whole duration of the disease is increased, and perhaps the termination more constantly fatal. The inflammation more frequently attacks the lower than the upper portion of the trunk, and more frequently the back than the abdomen. It has also a greater tendency to become erratic than similar affections of the face; and when, as it often does, it termi-

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nates in effusion of pus among the muscles, the patient seldom recovers.

The extremities are more commonly the seat of erysipelatous inflammation than the trunk, and the lower extremities are more frequently affected than the upper. When these parts are affected, the fever is less severe than in erysipelas of the head; but the local symptoms are generally more formidable, for the degree of heat is greater and the pain so severe, that the weight of a sheet can hardly be borne. The inflammation likewise often involves the lymphatic vessels and glands, which can now be traced by white or red lines for many inches, as from the knee or elbow to the inguinal or axillary glands, which sometimes enlarge and suppurate. If the erysipelatous inflammation ends in suppuration, the abscess is always diffuse, and the swollen limb gives a peculiar sensation to the hand, and which has been compared to what a person feels on passing over a quagmire. The dark, black, discoloured appearances of gangrene are too obvious to render any description of the parts so affected necessary.

*Diagnosis.*—The diagnosis of erysipelas is in general easy. For a few hours, perhaps, if a joint be attacked, it may be mistaken for acute rheumatism; or if a surface be attacked, it may be confounded for a short time with erythema, but the intumescence and spread of the disease quickly enable us to rectify the error.

*Prognosis.*—This disease is so influenced by treatment that it is difficult to estimate the proportion of deaths to recoveries. Some practitioners give as a result one death in three; while others affirm it to be only as one in ten, or even a much larger number.

*Treatment.*—Broussais states, that when he served with the French armies in Italy, he has seen erysipelas, for want of medicine, allowed to run its natural course, and that the result was, it made immensely rapid progress, and ended either in suppuration, in gangrene, or in fatal visceral inflammation. Some mode of treatment is therefore imperatively necessary to control this too often fatal disease, and it is to be regretted that the profession are not as yet unanimous as to the means to be adopted.

Erysipelas is admitted to be a highly inflammatory disease; and in the opinion of one party it is a disease of simple inflammation, and consequently ought, like the other phlegmasiæ, to be treated by general and local bleeding; while on the contrary, the opposite party contend that it is a specific inflammation, and that a long experience has shown that bleeding is often injurious, and that a tonic mode of treatment is much more uniformly successful.

There are very few physicians, from the days of Hippocrates to the present time, who have not bled in erysipelas, and consequently this experiment has been made on a large scale; still many of the warmest advocates of bleeding allow that operation to be occasionally followed by many unpleasant consequences. Mr. Lawrence, for example, speaks of having obtained much success by this treatment; but in seven cases of idiopathic erysipelas which he details, and in which bleeding was adopted, in one he was obliged to have recourse to bark; while in another the disease ran on from April to August. He also gives seven cases of traumatic erysipelas, which he likewise treated by copious general and local bleeding, but with so little success that he was in all of them driven to the unhappy necessity of making his long incisions on account of suppuration taking place.

In France, Dupuytren also adopted a similar treatment, in the belief that erysipelas was a disease of simple inflammation, and that energetic bleeding was necessary to subdue it. He gives five cases; and of these, two died; a third party lost the use of a limb; while in a fourth, the disease, notwithstanding the treatment, continued to spread; and the fifth only appears to have entirely recovered.

The treatment by bleeding, it has been seen, has been often followed by so many unfavourable exceptions, that many physicians, the most intelligent of the profession, affirm that, according to their experience, that practice is not only unfavourable but highly injurious. Andral is reported to have said, "in erysipelas with delirium bleeding pales the skin, but the disease continues; the cellular tissue remains gorged, and death follows. We open the body but find nothing." Cruveilhier says, "*des erysipèles rentrés*" is a consequence of unusual or too abundant bleeding, and he considers the question of bleeding, in this disease, to have been "*depuis longtemps jugée.*" Blache and Chomel likewise say that "experience has proved that general bleeding has no other effect than to blanch the eruption without notably abridging its duration." In this country, Drs. Fordyce, Wells, Pearson, Heberden, and Willan all give their testimony to the frequent ill effects of bleeding in this disease; and, in consequence, they, for the most part, recommend a tonic treatment, or by bark; and many practitioners have gone so far as to affirm that bark is a specific for this formidable disease. There seems no reason, however, for considering bark to be a specific for erysipelas, though a highly useful adjuvant, for it seldom favourably influences the disease till the tongue becomes brown and dry, and the patient consequently reduced to a state of much danger. Indeed, a long experience in the wards of St. Thomas's Hospital has rendered it probable that a treatment by wine is much superior to that by quinine or bark, and greatly so as a general principle to that of bleeding. The mode, then, of treating acute idiopathic erysipelas, whatever be the part affected, and with whatever symptoms accompanied, is to put the patient at once on a milk diet, to open his bowels, and to exhibit 4, 6, or 8 ounces of wine diluted with water, or with sago, or arrow-root, in the 24 hours, according to the severity of the symptoms. This mode of treatment cannot be instituted too soon, and it is seldom necessary to vary it throughout the whole course of the disease; for the delirium, if present, is generally tranquillized, or, if absent, prevented; the tongue, also, more rarely becomes brown, or only continues so for a few hours, while the local disease seldom passes into suppuration or gangrene. In a word, all the symptoms are mitigated and the course of the disease shortened. In a very few cases, however, something more is necessary to be done, and then quinine, gr. j. to ij., may be given with great advantage in very severe cases every four or six hours; and again, a few apparently hopeless cases have been saved by a drachm of quina in half-a-pint of barley water thrown up as an enema every night. In very mild cases, as in erysipelas after leech-bites, the disease may be in a great measure left to itself, or be treated by some slight purgative, to which it readily yields. Many other methods of treatment have been recommended, as by tartarized antimony, purging, &c.; but these modes do not appear to have been by any means generally successful.

The general treatment is, by most practitioners, accom-

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Elementary Principles of Medicine.

panied by some *local* treatment, as blisters, poultices, fomentations, cold lotions, the application of mercurial ointment, drawing a line of limitation with lunar caustic, punctures with the lancet, the application of leeches, and large incisions through the integuments and down to the fascia. The value, however, of any or of all of these auxiliaries in idiopathic erysipelas is extremely doubtful; for even the most simple, and apparently the most applicable, or cold lotions, are supposed by Cullen and many other close observers to favour the formation of pus.

The treatment of the part, after suppuration has taken place, is a free opening, poultices, and the ordinary rules of surgical treatment.

*Dietetic and preventative Treatment.*—It is essentially necessary that the patient should be restricted to a farinaceous diet and to slops till he is decidedly convalescent. The preventative measures are cleanliness, separation, and ventilation; and the attendants should be cautioned of the great probability of their contracting this disease in the event of any contravention of these rules.

### Of Hooping-Cough.—*Pertussis.*

Hooping-cough is a disease in which the poison produces a slight catarrhal fever followed by a peculiar paroxysmal cough.

The origin of hooping-cough appears to be of no distant date. Sprengel not having been able to trace it beyond 1510, when it was endemic in Paris; but its epidemic character was not determined till 1580, when it destroyed a prodigious number of children throughout Europe. This disease prevails now all over the world, or from the North Pole to New Holland. It is of much fatality, 8165 persons having died of this disease in 1839 in England and Wales. This poison, like that of the exanthemata, has the property of exhausting the susceptibility of the patient to its future actions on the first attack.

*Remote Cause.*—The fact of the susceptibility to this disease being exhausted on the first attack is a sufficient proof of the hooping-cough being caused by a particular agent; but in what manner this agent is generated is not determined. This disease is always sporadic, sometimes epidemic. The reports of the registrar-general for the year 1839 show that 1674 died in the winter quarter, 1208 in the spring quarter, 644 in the summer quarter, and 787 in the autumnal quarter; but the returns at present are too few to allow us to determine whether this ratio as to season be constant. The poison has probably a telluric origin.

*Predisposing Causes.*—The predisposition to this disease is so strong that few persons pass the period of childhood without suffering from it; but it may occur at any subsequent age. The early age at which the large majority of patients pass through the disease is, however, a sufficient reason for our very slight acquaintance with the predisposing causes.

When the hooping-cough is once excited, the patient's person secretes a poison which is both infectious and contagious.

*Infectious.*—The public are unanimously of opinion that hooping-cough is infectious, and no parent will permit his yet unaffected child to mingle with such as may be labouring under the disease. The profession, also, are, with a few exceptions, of the same opinion. It is supposed to have been first introduced into Van Diemen's land by a female prisoner, and subsequently to have spread both to the settlers and natives.

The infecting *distance* of this poison must be considerable, from the utter impossibility of isolating the little patient at home, or of preventing the spread of the disease in schools and asylums.

*Contagious.*—Since no cutaneous eruption accompanies this affection, the fact of its contagious nature cannot, as in the exanthemata, be strictly demonstrated. The communication, however, of this disease by *fomites* is an *a fortiori* proof this law.

*Fomites.*—Rosen conceives that, without being aware of it, he has often carried the disease from house to house. Frank also says it is often propagated from patient to patient, from house to house, and from village to village. Lombard says, that in Geneva, he has often traced the first cases occurring in that city to a neighbouring town, or to a sick child from the country. It was some years ago introduced into St. Helena, where it proved greatly fatal, the captain of a ship having some children labouring under hooping-cough on board having been allowed to send their dirty linen on shore to be washed.

*Susceptibility exhausted.*—The hooping-cough, as a general principle, affects the same person but once, and the exceptions to it are exceedingly few. Blache, however, gives a remarkable instance of a grandfather and grandmother catching it a second time from their grandchild, and all of them labouring under the disease together.

*Co-exists.*—The poison of the hooping-cough may co-exist with many other poisons, and in this case they often greatly influence each other's actions. The small-pox and hooping-cough have often co-existed; and a very common and fatal combination is measles and hooping-cough. Hooping-cough and cow-pox is not unfrequent. Indeed, the lower classes look upon vaccination as, in many instances, a cure for the hooping-cough.

*Modes of Absorption.*—If the law be established, that the hooping-cough is both contagious and infectious, it follows that the poison must be absorbed both by the mucous membranes and by the cutaneous tissue.

*Period of Latency.*—Our knowledge of this fact is at present extremely imperfect, but the more received opinion is, that the period of latency is about five or six days.

*Pathology.*—The theory of this disease is, that the poison produces slight primary fever, which for the most part subsides on the specific or secondary actions being set up, which are disordered actions of the pulmonary and gastric branches of the eighth pair, causing the peculiar cough and vomiting. It seems probable, also, that this poison has a tertiary action on the mucous membrane of the intestinal canal, and also on the substance and membranes of the brain.

The hooping-cough, in its earliest stage, is merely a disease of function, and often continues so throughout its whole course; for many cases have been examined in which no trace of inflammation, or other disease, has been discovered in any part of the body. If, however, the disease be of greater intensity, it very commonly produces structural disease of the lungs, stomach, intestinal canal, or of the membranes of the brain.

Rostan says, "I have examined some children that have died of this disease with great care, and I have constantly found alteration of structure of the respiratory organs. The most common of these alterations is

peripneumony, either single or double, with pleurisy and catarrhal inflammation of the bronchial membrane." These facts being corroborated by every writer, there can be no question but that this poison acts on the pulmonary branch of the eighth pair.

Dr. Watt, on examining the body of his son, Robert Watt, found, "on laying open the stomach, the internal surface had numerous red streaks, the marks of inflammation. There was also an universal crust of exudation, and much of it was collected on the upper surface, and not owing to the position of the viscus." In two cases that died at the London Foundling Hospital, in addition to the usual inflammatory appearances of the lungs, the mucous membranes of the stomach were in each case singularly red and injected. Both stomachs, also, were filled with the glairy matter vomited up in the disease. This poison consequently acts on the gastric portion of the eighth pair.

With respect to the tertiary actions of the poison, we occasionally, on opening patients that have died of hooping-cough, find the glandulæ aggregatæ vel segregatæ considerably enlarged, a circumstance which can hardly be considered accidental, when Blache states it existed in five cases out of nine that he examined. It has been a question whether the cerebral symptoms were the result of the violence of the cough, or of a tertiary action of the poison, but the latter theory seems the most probable. The patient sometimes has died with formidable convulsions, and yet no alteration of texture been discoverable. When, however, lesions of structure do exist, the membranes are injected, and serum effused into their cavity, and into the lateral ventricles. The substance of the brain, also, has more puncta cruenta than usual, and some very limited portions are said to have been found softened.

*Symptoms.*—The symptoms of hooping-cough arise out of the previous fever, the cough, vomiting, and also the different inflammations with which it may be accompanied.

The law that fever precedes the cough, though generally true, has many exceptions; for the paroxysms of cough are often established, and more particularly in summer, without being preceded by any febrile phenomena. The severest attack, indeed, seldom confines the patient to his bed, so that it rarely exceeds that accompanying ordinary catarrh. Hooping-cough varies greatly in intensity, and is, therefore, divided into

*Pertussis mitior* and into *Pertussis gravior*.

Most authors divide the group of symptoms of hooping-cough into three stages. The first stage comprehends the period from the first symptoms of illness until the hoop confirms the nature of the cough. The second stage commences as soon as the nature of the cough is determined, till the violence of the cough and the danger of the inflammation be past. The third stage is the convalescence of the patient, until the final and happy termination of the disease, or else the occurrence of those symptoms which destroy the little sufferer.

*First Stage.*—The early symptoms of the hooping-cough, and more especially in the spring and fall, are those of a common cold—as hoarseness, sneezing, a watery discharge from the eyes and nose, much uppression of the chest, a short dry cough, and such fever and other derangement as usually attend an ordinary cold. This stage usually lasts from one to eight days, but Willan has estimated it from one to two or three weeks, and Lombard has extended it to six or eight weeks.

*Second Stage.*—It is not until the fever remits, and is about to pass away, that the cough, which had distressed the patient, is followed by the characteristic hoop. On the occurrence, however, of this symptom, the disease is fully formed, and now consists of a series of fits or paroxysms of severe coughing, which occur at uncertain periods, while, during the interval, the little patient often enjoys his usual health, recovers all his gaiety, returns to his play, and relishes his food with good appetite. A paroxysm, or fit of the hooping-cough, is as follows:—

The approach of the fit is often denoted by an unpleasant titillation of the glottis, by a sharp pain in the chest, or else by a spasmodic contraction of the diaphragm. As soon as the child is thus warned, he instinctively runs to his nurse, and either grasps her arms, or lays hold of her chair, to support himself during the paroxysm, which in a few minutes or a few seconds is about to follow. In severe cases the cough is quite convulsive, and so rapid is the action of the diaphragm, that the air is almost instantly expelled from the lungs, and the patient, half suffocated, turns black in the face, and frequently passes his urine. At length the crisis approaches, the diaphragm relaxes, and a violent inspiration follows, accompanied by the characteristic hoop. This sound perhaps remits, but after a few seconds returns; and thus convulsive inspirations and expirations continue, till the patient is at length relieved by a copious expectoration, or else by vomiting. The matters expectorated from the lungs are frequently thick, viscid, and muciform. When vomited from the stomach, the patient throws up a glairy fluid of much tenacity, semi-transparent, and frequently amounting to the greater part of a pint; and should he have recently eaten, the food often returns with it. It frequently happens, however, that the stomach, by a sort of election, retains the food, and rejects the offending matter. If the fit be violent, the fluid rushes not only from the mouth, but also from the nostrils; and in some instances is mixed with blood, for blood occasionally bursts in considerable quantities from the congested vessels of the mouth, the nostrils, the ears, the eyes, and in some instances also from the lower parts of the body.

If the stethescope be applied to the chest previous to the fit, we sometimes detect the mucous rhoncus, common to catarrh; yet in most cases the respiration is natural. During the act of coughing, the respiration is completely suspended, and not sensible to the ear in any part of the chest. On the hoop, however, taking place, the air is heard to rush with remarkable violence into the trachea; but at this point it stops for one or more seconds till the bronchial tubes relax, and the air is then admitted into the lungs.

The fit having subsided, the eyes, which had nearly started from their orbits, resume their natural position, but are inundated with tears, or else the conjunctiva is more or less gorged with blood: the natural expression and appearance of the countenance returns, and in a few minutes, in favourable cases, the good spirits of the little patient are renewed, and he eats with appetite. On the contrary, in severe or unfavourable cases, long-continued exhaustion, headache, and some fever, are the preludes to convulsions, inflammation, or the other severest forms of the disease.

The paroxysm varies greatly in frequency and severity, but in general its frequency is as its severity. In ordinary cases it returns every two hours, but in

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severer cases, and especially during the second and third week, it returns every half or every quarter of an hour, or even oftener. This disease commonly reaches its acmé at the end of the third, fourth, or fifth week; after which the paroxysms diminish in frequency, the intervals are prolonged, and the patient is to a certain degree convalescent. The duration of this second stage is from two to six or eight weeks.

*Third Stage.*—The third stage commences with the convalescence of the patient, when the paroxysms become milder, the intervals longer, the expectoration more natural and less in quantity, and the vomiting ceases, so that the general health of the patient is much improved. The duration of this stage, however, is often long and variable, and the cough may still harass the patient for many weeks, or even many months. It is to this stage that the term chronic is usually applied.

The whole duration of the stages of hooping-cough are liable to greater variations than in almost any other disease; for this complaint may terminate in two or three days, and after a very few paroxysms, or it may last two, three, or four months, or even more than a year. Lombard has given a calculation of the number of paroxysms of an ordinary attack, and he estimates them at three hundred and eighty-three day paroxysms, and four hundred and fourteen night paroxysms.

Such is the progress of an ordinary case of pertussis mitior, or as long as the disease is limited to mere neuroses of the parts affected; but in particular seasons, and in particular persons, many accidents may arise to complicate the symptoms, and to increase the danger, as inflammation of some of the tissues of the lungs, of the mucous membrane of the stomach or intestines, or of the serous membranes of the brain.

Inflammation of the mucous membrane of the bronchia is the most usual complication of the hooping-cough. The form of inflammation may be that in which the secretions are in defect, so that the mucus is not only greatly diminished in quantity, but is thick and viscid, teazing the patient with fruitless efforts to free it from the lung, and thus causing a frequent recurrence of the paroxysm. In other cases it may assume the form of purulent inflammation, the pus secreted being formed into sputa, and moderate in quantity or else it may be thrown up pure, as from an abscess, and so enormous in quantity as to amount to one or two pints in the twenty-four hours. The inflammation of the bronchial membrane may spread to the substance of the lungs, when the danger, as well as the symptoms of some of the various forms of pneumonia will be added to the disease; but the most formidable accident is when the pleura is inflamed, for then the patient's sufferings during the paroxysm are fearfully increased, from the agonizing pain inflicted during the paroxysm of the cough.

The mucous membrane of the stomach and intestines is also often the seat of inflammation; and this is denoted by pain in the epigastrium, and by the suppression of the glairy fluid thrown up by vomiting, so that on the termination of the fit the patient often lies in a state of complete exhaustion, unable to discharge anything either from the stomach or lungs, or even to hoop, and he is now said to labour under the *dumb kink*.

In mild cases the bowels are little affected in this disease, except that the patient sometimes passes his fæces during the paroxysm. In severe forms the stools are often either black and offensive, or else consist of a colourless mucus, the latter evidently depending on an inflamed state of the mucous follicles.

Headache is a symptom which usually attends the catarrhal stage, but generally ceases when the fever subsides. In some instances it continues throughout the disease, and is not unfrequently the forerunner of fatal convulsions, or epilepsy, or else of inflammation of the membranes of the brain, terminating in delirium, coma, hydrocephalus, and death.

*Diagnosis.*—It is impossible to determine whether the febricula of the first stage is the result of simple catarrh, or will, on its subsiding, prove to be hooping-cough. As soon, however, as the cough has been followed for two or three paroxysms by the hoop, the diagnosis is perfect, no other disease being accompanied by this symptom.

*Prognosis.*—The proportionate number of deaths to recoveries, in hooping-cough, is not determined, but it greatly varies in different years; for in one year, says Frank, hardly a death will occur from this cause in a large city, while in another year many children will fall. In general, however, pertussis mitior is rarely fatal, while pertussis gravior is very commonly so. Lombard thinks station in society greatly affects the mortality; for he says, and may fairly assert, that of ten fatal cases nine belong to the poorer classes. The reports of the registrar-general show that the mortality is greater from this disease in towns than in the country, being in the metropolis, in 1838, ·111 per cent., while in England and Wales it was only ·061. In the year 1839 also, it was for the metropolis ·061 per cent., while for England and Wales it was ·053. Lombard gives the ages of 40 fatal cases as follows:—

| | | | | |
|---|---|---|---|---|
| From birth | to | 6 | months | 6 |
| „ 6 | to | 12 | months | 7 |
| „ 1 | to | 2 | years | 10 |
| „ 2 | to | 3 | ditto | 6 |
| „ 3 | to | 4 | ditto | 7 |
| „ 4 | to | 5 | ditto | 2 |
| „ 5 | to | 6 | ditto | 2 |
| „ above | | 6 | ditto | 0 |
| | | | | 40 |

*Treatment.*—The stage of invasion is seldom marked by symptoms of greater severity than those of common catarrh, and consequently, except putting the patient on a low diet, and attending to his bowels, there is little occasion for medicine, especially as the diagnosis can hardly be said to be yet complete.

The hoop having confirmed the nature of the disease, and the second stage established, the disease will now run its course, and two indications of treatment present themselves. The first is to prevent, if possible, convulsions, or any attack of inflammation, either of the lungs, the stomach, or of the membranes of the brain. The second indication is, after the period of danger is past, to prescribe such medicines as may interrupt the course, and anticipate the time of the spontaneous cessation of the disease.

The best mode of obviating the danger of cerebral irritation, or of inflammation of any of the organs that have been mentioned, is to mitigate and control as far as possible, the frequency of the paroxysms, to check those secretions which are in excess, and to excite those which are in defect, and these objects are best obtained by mild opiates, combined with gentle purgatives or laxatives.

The choice of the opiate has been considered a matter



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of much importance. The continental physicians have bestowed much praise on belladonna, others on hemlock, others on henbane, while others have contented themselves with opium. It must be admitted, however, that neither of these narcotics possess any specific property in controlling this disease, so that the selection of the particular one must be left to the discretion of the practitioner. But supposing the patient to be a child, as the head is especially the organ to be protected, the mildest, as hyoscyamus, or the syrup of poppies, are the safest and best. Should, however, belladonna be selected, if the child be under 4 years of age, the dose ought not to exceed one-eighth of a grain; or if hyoscyamus, half a grain to a grain, every six or eight hours; while if it be the syrup of poppies, this medicine should be given in such fractional doses of a drachm as are suited to its age.

But an opiate, in the early stage of the disease, ought not to be administered alone, and some purgative or laxative ought, as a general rule, in all cases, to be combined with it. The selection of the particular medicine is perhaps unimportant, and any vegetable or saline purgative will perhaps answer equally well, as the confectio sennæ, rhubarb, or castor oil, or manna. The neutral salts, however, sit easiest on the stomach, and, as the medicine must be continued, are the most agreeable to the patient; and the best combination for children, perhaps, is syrupi papaveris c. magnesiæ sulph. āā ʒ ſs. to ʒ j. ex. mist. camphoræ 6tis vel 8vis horis. This prescription generally puts this disease in a safe train, and is, in many instances, all that is necessary to insure its termination in a moderate time.

Towards the close of the second stage the symptoms may, in a few instances, become unfavourable, and cerebral irritation, with convulsions, or inflammation of the membranes of the brain, of its substance, or of the tissues of the lung, or of the alimentary canal, may complicate the disease, and now the treatment of the case is always exceedingly difficult, and frequently unsuccessful.

If the convulsions should come on suddenly, and without headache, or other symptom of inflammatory action, small doses of any opiate, and mustard poultices to the feet, often relieve the patient; but should the convulsions still continue, an assafœtida injection may be thrown up. It often happens that the convulsions are combined with a suppression of the vomiting, and of the usual glairy discharge; and in these cases leeches, followed by a large linseed poultice, should be applied to the epigastrium. If the disease should proceed, and headache or other symptom show an affection of the membranes of the brain, leeches should be applied to the temples and cold to the head.

When the poison excites inflammation of the tissues or substance of the lungs, bleeding to a limited amount is imperatively required; but we should be satisfied with such mitigation of the symptoms as may obviate immediate danger, and even that is not always obtained, since the affection is not to be subdued by bleeding, as in simple inflammation, for, being dependent on the action of a morbid poison, it will run a given course. Blache, for instance, bled in nine cases, either with the lancet, by leeches, or by cupping, and in one case no less than five times; yet, he adds, with a desolating want of success, and eight out of the nine cases terminated fatally. This result makes him add an axiom, in which every practitioner will agree, that there is in severe hooping-cough, as in typhus, cholera, and many other affections, an unknown element which controls all these intercurrent inflammations.

If the intestinal canal be affected, some sharp purgative, combined perhaps with calomel, may be necessary, to act on the bowels and free them from their contents; and, if the stools be white and mucilform, and the patient not relieved, an enlarged state of the follicles may be suspected, and consequently a large linseed poultice should cover the abdomen for some hours, preceded, perhaps, by an enema of syrup of poppies and barley-water, and which afterwards should be thrown up night and morning. Many other modes of treatment have been recommended for the cure of hooping-cough, and more especially a treatment by emetics repeated every second day; but, as the emetic is admitted to have no specific property, it seems difficult to understand how its action can be salutary, especially as in most instances the patient throws up, in a greater or less degree, after each paroxysm of coughing.

The disease having passed into the third stage, and the inflammation or other threatening symptom, if any has existed, having subsided, it is desirable to attempt to abridge the duration of the cough, which often extends to a most distressing length; and for this purpose tonics, anti-spasmodics, and other remedies, either external or internal, have been recommended.

The more stimulant anti-spasmodics, as assafœtida, musk, castor, oil of amber, cantharides, and camphor, are the remedies which have obtained the most suffrages in the cure of this stage of the hooping-cough. But the two first are most esteemed, and some persons even consider assafœtida to be a specific, not only in this, but in every other stage of the disease. Cullen, however, preferred cinchona to assafœtida, and considered it "the most certain means of curing the disease." Many other remedies have been mentioned, as alum, hydrocyanic acid, oxide of zinc, arsenic, and many preparations of iron, and all of these remedies have perhaps been found to a certain extent useful; but in estimating the results of remedies, however, we should be careful not to mistake recovery for cure.

When internal remedies have failed to make any impression on the hooping-cough, the cure is often attempted by means of local treatment, or by derivatives. The early physicians applied actual cautery to the nape of the neck; the modern ones, blisters to the spine, or have directed the back to be rubbed with the unguentum antimonii cum potassio tartarizati, or with some liniment or embrocation, as the linimentum camphoræ, linimentum ammoniæ, or with assafœtida, oil of amber, oil of turpentine, or the tincture of cantharides. The general opinion, however, is, that these do little good unless they contain some opiate, whose absorption they facilitate. Nevertheless, "*Ne crede tali auxilio*" is a truth, however, too often inculcated as the result of their employment. Foot baths and the warm bath have also been used, and often with much efficacy.

When ordinary remedies have failed a change of air is a resource of great value, and was first mentioned by Dr. Forbes, in his thesis *De Tussi Convulsivi*, in 1754; and since that period it has been recommended in dangerous cases by most physicians, with that praise it so eminently deserves. It is determined that a change from the bad air of a town to the purer air of the country is at all times of great benefit; but Lombard contends that he has found a change from the country to

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the town to be beneficial, and that the patient is benefited even by a removal of so short a distance as half a mile. Indeed, it is impossible to witness more striking instances of the advantages of treatment than we occasionally observe in patients when removed from London to the environs, for in a few hours they often recover from an apparently hopeless state.

*Dietetic and General Treatment.*—The patient should not be allowed animal food from the commencement almost to the termination of the disease. It is desirable also that the temperature of his apartment should be regulated, and that he should not be exposed to any considerable or sodden change from heat to cold. In mild weather also, if no local symptom forbids, he should be permitted to take exercise in the open air. He should likewise be recommended to wear flannel.

There are no known means of prevention, except an entire removal from every source of contagion.

Of the Cow-Pox—*Vaccinia.*

The cow-pox is a simply contagious disease, the poison producing a single vesicle at each point of puncture. No death from this cause is recorded in either of the reports of the registrar-general.

This poison is the only beneficent agent known in the whole range of morbid poisons; is immediately derived from the cow; and has the singular property of destroying the susceptibility of the human frame to the small-pox, the most virulent contagion we suffer from. Our knowledge of the anti-variolous properties of this poison is due unquestionably to Dr. Jenner, who introduced it into medicine in the year 1798. The necessity for such a remedy arose out of the circumstance, that notwithstanding the general safety of the patient by inoculation, still the time and expense necessary to enable him to undergo that operation were so considerable that a large portion of the population were altogether unprotected. The practice of inoculation consequently was only a means of more widely extending the disease; and it was calculated, from data submitted to a committee of the House of Commons, that for the fifty-five years preceding the introduction of inoculation the proportionate mortality from small-pox was as 72 in 1000, while in the last thirty years of the past century it arose to 95 in 1000. Inoculation consequently was a protection to the rich, but it was destruction to the poor, and hence the necessity of this antidote, of which Dr. Jenner so ably and so successfully availed himself.

*Remote Cause.*—The remote cause of this disease in the cow is probably a poison existing in the atmosphere, but whence derived is quite unknown. The disease, however, for the most part prevails epidemically, and so irregularly, that Talleyrand wrote in 1831 to the French government, desirous of obtaining vaccine matter from a new source, that, after the fullest inquiry, the cow-pox had not prevailed among the cows in this country for more than twenty years. In France it had not been met with up to that time; but in the year 1836, by an inexplicable *bizarrerie*, it broke out in three separate districts in that country, at Passy, at Amiens, and at Rambouillet.

It is singular, looking to the deep interest connected with the subject, that we are still unacquainted with the exact nature of the vaccine disease as it occurs in the cow, for Dr. Jenner has left us no drawing, and only a very imperfect description of the eruption from which he vaccinated. The difficulties which surround this question will be seen when it is stated that Dr. Heim contends that the cow is subject to no less than eight distinct forms of cow-pox, five of which are communicable to man. Indeed there is no sort of agreement among authors in their description of the cow-pox in the cow: for some describe it as a local disease of the teat, and void of fever; others, as a local disease with fever. Everybody describes the pock as multiplex, and Jenner is supposed to have obtained his first lymph from an epizootic in which the eruption extended from the extremity of the tail to the base of the horn. The last, and perhaps the best, account of the cow-pox in the cow is that of Mr. Ceely, who observed the disease recently in Buckinghamshire, and who has published a description of it, with drawings, in his *Variolæ Vaccinæ*, and has thus laid the foundation for more accurate observation on this interesting subject.

The poison derived from the cow is capable of producing the cow-pox in many animals, as the dog, the goat, the ass, the sheep, and perhaps the horse. Its most important transmission, however, is to man; and matter taken from the cow produces in the human subject the peculiar disease termed the cow-pox; but supposing the pustule to be multiplex in the cow, the disease is so modified that only one pustule, as a general rule, results at each point of puncture in man. Matter taken from the human subject is said, by retro-inoculation, to produce the vaccine disease in the cow; but now, strange to say, if the original disease has been correctly observed, it gives one pustule at each point of puncture, and no more. The laws of the cow-pox virus, when introduced into the human subject, are as follows:—

*Predisposing Causes.*—As a general principle, to which there are few exceptions, all ages and both sexes are equally liable to this affection. The adult, however, is less susceptible of this poison than the child, and often requires to be vaccinated two or three times before the disease is produced. As vaccination is practised merely as a preventative of the small-pox, it may be necessary to state that, of 8714 deaths from small-pox in 1839, 2235 took place in children under one year old. It will be plain, therefore, that the earlier the little patient can be vaccinated consistent with its health the better.

*Contagious.*—The contagious nature of this disease is the basis of its use in medicine; and the vaccine poison is found intimately combined with the lymph, the pus, or the crust of the vaccine vesicle. It is most energetic, however, in the lymph; less so when combined with the pus; and most feeble of all in the crust; so much so that Bousquet thinks if the latter be formed on a pustule in any way broken or interfered with, it is entirely useless and inert. An analysis of vaccine lymph has given nothing but water, albumen, and some rudimentary crystals common to all serous fluids; the specific agent escaping detection. The lymph can be preserved in an active state at an ordinary temperature between two plates of glass for a considerable time; but if heated to 120°, or if frozen, it loses the power of communicating the disease.

*Fomites.*—The fact of vaccination is a sufficient proof of this law.

*Susceptibility exhausted.*—As a general law the vaccine disease affects the individual but once during life. The more remarkable circumstance, however, is that the vaccine poison not only protects the constitution against itself, but also against the small-pox, and reci-

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procally the small-pox poison protects the constitution not only against itself, but also against the cow-pox virus. It is upon the presumption that this rule is true that the cow-pox has been introduced into medicine as a preservative remedy against the small-pox. On its first introduction the law was supposed to be universal, but each year's experience has shown numbers of persons susceptible of a modified small-pox, or other more severe form of that disease, after vaccination. The consideration, therefore, of the proportionate number of exceptions to the alleged law is one of the most important questions connected with vaccination, and must determine the actual value of this great discovery.

Dr. Jenner ever entertained the opinion that the vaccine and small-pox virus were essentially the same; he inferred, therefore, that as the patient was occasionally attacked a second time with small-pox, so that vaccination would fail in protecting the system from small-pox in an equal number of instances, or in about one in one hundred. The number of cases of failure, however, are unhappily greatly beyond this proportion, for Bousquet thinks that in the epidemic in Marseilles, one in fifteen of the persons vaccinated took the small-pox; and it results from the best data we at present possess, that in about one person in twenty vaccination loses its protecting influence altogether, or else ceases to guard the constitution beyond a period varying, perhaps, from two to ten years, when the party again acquires a susceptibility to an attack of small-pox; an attack, however, so modified, that the proportionate mortality from small-pox after vaccination is only seven per cent., while the rate of mortality from the natural small-pox, the party not having been vaccinated, is no less than thirty-six per cent., or five times greater.

It is certain, also, that the constitution of a vaccinated person does, in a given number of cases, acquire a fresh susceptibility to the vaccine virus, and sometimes so rapidly that, according to Roueh, modified vesicles may be obtained at a very short period after vaccination. These circumstances may appear to diminish the great value of vaccination; but in estimating the actual result of this practice to the community, we find that nineteen twentieths of the population are permanently protected from the small-pox. Again, if we suppose the calculation to be correct that 40,000 persons died in England and Wales from small-pox in 1800, when the population, according to Mr. Finlaison, was only 9,187,186, the total mortality, taking the estimated population in 1838 at 15,324,720 persons, should in the present day be at least 70,000; but the numbers that died from that disease in 1839 were only 9,131, showing a diminution of mortality from this cause of more than six-sevenths in England and Wales. In short, the reasons for preferring vaccination to inoculation is the annual preservation of more than 60,000 lives.

*Co-exists.*—The vaccine virus is capable of co-existing with many other poisons, as with that of syphilis, of scarlatina, of measles, or of the hooping-cough. But although cow-pox often exists contemporaneously with those diseases, yet we constantly find the one modifying or suspending the course of the other. Of all the complications of the cow-pox with other morbid poisons, that with the small-pox is fraught with the greatest interest, and we find these two diseases co-existing, preceding, and following each other. If the poison of the cow-pox and of the small-pox be separately inserted in different places, for instance, in the same person and at the *same time*, or within *a week* of each other, both diseases form, co-exist, and each pursues its respective course. The lymph also from the vaccine vesicle will produce the vaccine disease, while that from the variolous pustule will produce the small-pox. Again, if the two punctures be near each other, one common areola will surround both punctures.

When a person has been inoculated with a *mixture* of the variolous and vaccine poisons, Adams states only one will take effect. This effect, however, is not uniform; for Bousquet inoculated three children with a mixture of the two poisons; two had the cow-pox only, but in the third the cow-pox preceded, continued its usual course till about the eighth day of the disease, when a slight eruption of the small-pox appeared.

If the patient be exposed to a variolated atmosphere at the time he is vaccinated, both diseases will probably result. If vaccine lymph be inserted four days after exposure to the infection of a variolated atmosphere, the two diseases may co-exist, or the one may precede the other. An example of this latter occurred a short time ago in St. Thomas's Hospital; a child that had been exposed to variolous infection for four or five days, was vaccinated, but the vesicle did not rise; a modified small-pox, or variolæ verrucosæ, appeared, and ran its usual course. This disease terminated, the vaccine puncture began to inflame, a vesicle formed, which, though small, ran its course, and had all the usual characters.

"When the small-pox and vaccine diseases have been inoculated about the same time," says Willan, "the eruptions in all the cases I saw were of the species vulgarly called the horn-pock, being hard, semi-transparent, and, though of long duration, did not maturate." This statement, as a general principle, is correct, but there are exceptions to it; Bousquet has given no less than sixteen cases in which the cow-pox and small-pox co-existed, and yet all the patients perished.

Variolous matter, inserted on the ninth day after vaccination, appears to have its actions wholly superseded. Bousquet, however, affirms that this protecting influence is imparted as early as the fifth day.

*Modes of Absorption.*—Vaccination shows that this poison is absorbed by the cutaneous tissue. One puncture is followed by one vesicle, which, when normal, is sufficient to give the fullest protection to the constitution; it is usual, however, to make three punctures on each arm, for the purpose of insuring a supply of lymph. The experiments of Sned show that the poison, after vaccination, is rapidly taken up, and the constitution immediately infected; for in no instance has he been able to prevent the disease, although he has, immediately after the puncture, washed that part with water, or a solution of ammonia, or of the chloride of soda. Bousquet has also attempted to prevent the formation of the vesicle by applying the cupping glass instantly over the punctured part, but although he has kept it on for fifteen, twenty, and even thirty minutes, till phlyctenæ have formed, and blood flowed in abundance, still in no instance has he been able to retard the occurrence of the disease.

Mr. Ceely says, that he has produced vaccine vesicles in young children without puncturing the skin, or merely by keeping lymph in contact with it, and excluding the air by a coating of blood.

*Period of Latency.*—The usual period of latency is

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two, sometimes three days; but when the system is under the action of other poisons, the period is often prolonged, and sometimes even three weeks have elapsed from the time of the puncture till the appearance of the vesicle.

*Pathology.*—The theory of this disease is—the vaccine virus is absorbed, probably infects the blood, lies latent in it a few hours, and then produces its specific action, or a pustule at each point of insertion.

The vaccine pustule runs a given course of varus and of vesicle, terminating by a concretion which forms the crust. The stage of varus lasts but one day. The vesicular stage is four days *umbilicated* and three *acuminated*. The process of incrustation is also three days, and that of detaching the crust three days more; so that, allowing three days for incubation, the whole duration of the disease from the time of puncture to the detaching of the crust is from fourteen to seventeen days. A slight fever usually occurs about the eighth day, and lasts about three days, and occasionally the whole course of the disease is accompanied by a slight fever.

The first day after vaccination we observe nothing but the redness, which is inseparable from every puncture. On the following day it is impossible to determine whether the vaccination has taken place. On the third day, however, sometimes a little earlier, and sometimes a little later, the punctured part is seen to be inflamed, and the varus of the future pustule is formed, and sufficiently elevated to give a sensation of hardness. On the fourth day the varus has considerably enlarged, and on the fifth a vesicle has formed on its apex, and lymph, in some instances, may now be collected from it. This vesicle is yet depressed at its centre, or *umbilicated*. Usually about the eighth day from the time of vaccination, or on the fourth or fifth from the appearance of the varus, the vesicle has attained its greatest size, and is from two to three lines in diameter. It is still umbilicated, its cuticle white and opaque, but a brown spot has appeared in the centre, which shows that the cellular bride which ties it down is about to rupture.

On the eighth day from the time of the puncture, a bright red areola encircles the base of the pustule; an appearance which led Jenner figuratively but happily to remark, that it was now "the pearl upon the rose;" between the eighth and eleventh day the cellular bride ruptures, and the vesicle fills or becomes *acuminated*. At this period the red areola enlarges, and is of a deeper red, while a slight fever, termed the "fever of vaccination," comes on, and lasts from three to four days. About the eleventh day the fever subsides, and between the eleventh and fourteenth days the pustule ruptures, and secretes a fluid which forms a crust. The inflammatory areola has already begun to abate, and generally before the seventeenth day the crust falls off, leaving the usual large round cicatrix.

The vaccine cicatrix is round, deep, radiated, and puckered, and is more marked in proportion as it is more recent, but is never entirely effaced by time. Considered anatomically, the vaccine pustule has been compared to a spice-box, being divided into a number of cells, separated from each other by a thin cellular tissue, each filled with a clear diaphanous fluid. These cells do not communicate together, but radiate from the centre to the circumference, the centre being bound down by cellular tissue, giving the umbilicated character to the pustule. This is the state of parts from the sixth to the ninth day; but it does not last, for the lymph now becomes turbid, is mingled with pus, the central bride is broken, the cells communicate, and the pustule rises, is acuminated, and ruptures.

Among the variations in the course of the pustule, Bousquet mentions, that he has several times seen—"plusieurs fois"—such differences in the development of the pustules, that some had run their course while others were only commencing it. M. Fribault has witnessed a fact still more extraordinary, or a pustule which had completed its course beginning *de novo*, and running through it a second time. A still more singular anomaly has also been witnessed, and more at variance with the usual laws of the vaccine virus, or a general cow-pox eruption. Bousquet gives a case in which the supernumerary pustules were so many, that he doubts whether the distinct small-pox ever presented a larger number. A similar case also occurred on the re-vaccination of the Prussian army. A case of this kind also occurred in the child of a gun-smith, in Oxford-street, and which at length died, exhausted by an incessant recurrence of pustules all over the body.

*Symptoms.*—It is seldom that any other symptoms than those which have been mentioned occur in the course of the disease, except some occasional eruption on the arm, as roseola, strophulus, or lichen, or some unimportant abscess or boil on the same part.

*Prognosis.*—The prognosis is always favourable.

*Diagnosis.*—The circumstances of vaccination of the single vesicle, and that at the point of puncture, render it impossible to confound this disease with any other.

*Treatment.*—The patient should abstain from animal food during the course of the disease; the state of the bowels should be attended to, and occasionally some slight local treatment is necessary, when the arm is considerably inflamed.

### Of the Poison of Syphilis.

Syphilis is a simply contagious disease, consisting of an ulcer termed the "primary symptoms," produced on any part of the body to which the poison may be applied, and also in a given number of cases of many "secondary symptoms," as cutaneous eruptions, warty growths; and also inflammation of the bones, of the ligaments, of the eye, of the nose, or of the throat. This disease often produces much unsightliness, frequently great suffering, and formerly many deaths; but in the present day, owing to the improvements in medicine, the mortality from this affection is trifling, only 142 deaths being recorded from it in the year 1839.

This disease is of modern origin, and first appeared in Rome towards the close of the XVth Century, supposed to have been brought from America by Columbus, but without any efficient evidence. The epochs in its history are the gradual development of its laws, and the connexion of the primary with the secondary symptoms; also the introduction, first of mercury, then of sarsaparilla, and lately of the iodide of potash, into its treatment.

*Remote Cause.*—The combination of causes producing this disease is entirely unknown; but so dissolute were the manners of the times, that, in a few years, it spread over the whole of Europe, and has at length perhaps infected every country in the world. The disease is now entirely propagated by human contagion, and the poison in its habits is peculiar to man, for in no instance has matter taken from the primary sore produced any similar affection in animals.

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*Predisposing Causes.*—The principal circumstances which predispose to syphilis are—impaired health, peculiarity of idiosyncrasy, neglect of personal cleanliness, intemperance, and climate.

In general the infection by this poison is more certain, its action more immediate, and its phenomena more severe, in proportion to the enfeebled health of the party. The effects of idiosyncrasy in predisposing to this disease will be seen, when it is stated, of the "filles publiques," some very few escape it altogether, and are never infected, while others may be said to pass their lives in the hospitals. Another remarkable instance of idiosyncrasy occurred in the case of twins born of infected parents, one of which was covered with a syphilitic eruption, while the other was perfectly healthy. The consequences of want of cleanliness and of intemperance in producing this affection are palpable. The effects of climate are remarkable in influencing the occurrence of syphilis; thus the admissions into hospitals for this complaint in the Windward and Leeward command are only 35 per 10,000 annually, while in Great Britain they are 181. The primary symptoms also are said to be milder in tropical than in northern climates, and perhaps owing to the greater cleanliness of the inhabitants. The secondary symptoms, however, have been thought to be more severe in Portugal, in the Bermudas, and in some parts of India, sometimes causing a large non-effective list, or a number of discharges from the service.

*Age* appears but slightly to affect the liability to this disease; for the infant at the breast, the adult, and even the aged occasionally suffer from it. The strong passions of youth, however, render it more common from early adult age to 30. The sexes probably suffer in nearly equal proportions.

*Contagious.*—The contagious nature of primary syphilis is generally admitted, for it is a disease which prevails exclusively among a class of persons indiscriminate in their sexual intercourse, while it is entirely wanting in those whose similar indulgences are guarded by a higher morality and a purer taste. Many persons in proof of this doctrine have voluntarily inoculated themselves, and the disease has in most instances followed. Ricord and Beaumés have also recently repeated Mr. Hunter's experiment of inoculating the diseased patient with matter taken from his own primary sores, and in an endless number of instances they have succeeded in producing "a specific primary sore."

The primary sore is very frequently followed by enlarged inguinal glands or bubo, and it has been a question whether matter from these parts will communicate the disease. The experiments of Ricord, however, have shown that a specific virus often can be obtained from the superficial ganglia, but not from the deeper-seated ones, unless the latter be contaminated by pus from the former. The pus also contained in the lymphatic vessels leading from a primary sore, or else in an abscess in its immediate neighbourhood, will also produce a syphilitic ulcer by inoculation.

It seems also established by Mr. Hunter, by Ricord, and by Beaumés, that pus from a syphilitic sore throat, or an inflamed periosteal membrane, or from any other part the seat of the "secondary symptoms," is incapable of producing any specific affection by inoculation, and consequently is not contagious, with perhaps two exceptions, or the ulcerated mouth of a syphilitic child, and also the "pustule muqueux" or warty excrescences, which sometimes form on the genitals. The ulcerated mouth of a syphilitic child, for instance, has sometimes occasioned ulceration of the nipple of the nurse that gave it suck, and this has been followed by slight or severe secondary symptoms. The cases, however, of this kind are few, and perhaps it may ultimately be shown that the disease may have been contracted in the primary form at birth, the mother being infected. The next form of "secondary symptoms" which is supposed to be contagious, are the warty excrescences growing from the genital membranes. Willan says, he has produced them in a healthy person by inoculation, while both Ricord and Beaumés have seen them spread from person to person in a manner difficult to explain, except on the hypothesis of contagion.

The intimate nature of the syphilitic virus is unknown, but its property of infecting is not immediately lost, for Ricord has preserved it in tubes in the same manner as vaccine lymph for seventy-three days, and then successfully inoculated with it.

*Fomites.*—The repeated instances of inoculation are proofs of the contagion by fomites. Ricord states that the nail is sometimes the instrument of transmission; and he gives instances of persons labouring under syphilis and the itch, who by scratching themselves had produced primary sores in different parts of the body.

*Susceptibility not exhausted.*—No prior attack, however severe, exempts the constitution in any degree from a second attack of syphilis. Even the existence of either the primary or of secondary symptoms does not prevent the patient from contracting other primary affections. Many unfortunate females in consequence of this law are scarcely ever free from the disease.

*Co-exists.*—The co-existence of typhus and syphilis, and of syphilis and erysipelas, is of daily occurrence. Syphilis and itch, syphilis and intermittent fever, are also very frequent. The frequent co-existence of syphilis and of gonorrhœa has given rise in the minds of some pathologists to the opinion that the two poisons are identical; but a multitude of experiments have shown that the matter of gonorrhœa will not produce syphilis, unless a chancre exists in the urethra. Neither will the matter of syphilis at any time produce gonorrhœa.

*Modes of Absorption.*—The poison of syphilis is introduced into the system by means of the cutaneous and mucous tissues.

*Period of Latency.*—The period usually observed to elapse after connexion till the appearance of the primary sore, is from four to eight days.

The period of latency which elapses before the secondary symptoms manifest themselves is usually long after the cure of the primary sore, or perhaps from six weeks to six months; but cases are numerous in which the period of latency of the secondary symptoms, and especially before the whole series is exhausted, is often singularly long. We constantly meet in the London hospitals with cases in which two, three, or four years have elapsed between the termination of the primary and beginning of the secondary symptoms, and some cases have occurred in which fifteen years have appeared to be the period of latency; and if this be true, a great part of life may pass away before the effects of the poison are entirely exhausted, and the disease eradicated from the system.

*Pathology.*—The theory of syphilis is that the poison is absorbed and mingles with the blood, and after a

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certain period has elapsed, produces a specific inflammation in the part to which it was applied and introduced into the system, and which is termed the primary sore. The primary sore being healed, the disease is in many cases at an end, but in a considerable number of instances, the poison remains circolating in the system in a latent state, although disarmed indeed of its power of producing any further primary sore, till at varying and at sometimes very distant periods it causes many "secondary symptoms," or affections of different tissues, as of the skin, the throat, the nose, of the bones, of the periosteum, the ligaments, and also of the eye; not however that the whole of this long series is in all cases set up, for the poison more commonly exhausts itself on one or more tissues only. Such is the theory of this disease. The proofs of the law that the poison is absorbed and mingles with the blood, are the long series of secondary symptoms which are often set up, and at very distant periods from the time of contamination, and also the infection of the fœtus in utero, a circumstance which is supposed to occur in the ratio of 17 in 1000 in the children admitted into the Hôpital des Enfans Trouvée.

The law that the poison produces a specific inflammation in the part to which it has been applied and introduced into the system is so universal, that it is doubted whether it has any exceptions. Mr. Hunter, however, thinks the poison may be absorbed, and the glands of the groin inflame without any primary sore having formed. This form of disease is termed by the French pathologists "bubo d'emblée," and Ricord thinks he has seen it when it was impossible to discover any antecedent or concomitant primary sore, while Beaumés says he has inoculated with matter taken from these buboes, and produced primary symptoms.

The law that secondary symptoms follow the primary sore in a given number of cases is unquestionable, and the returns of the army give one case in fifteen as the proportion.

### Primary Syphilis.

The primary ulcer is so much influenced by the constitution of the patient, his present state of health, and perhaps by some modification of the poison, that it is difficult to give any generic description of it. We should imagine ulcers resulting from inoculation must be most uniform in their character. Ricord however states, that although inoculation as a general rule gave a characteristic ulcer, yet they often presented differences so great as apparently to constitute different diseases. Indeed he adds, it is not the form, the induration, or other material circumstance which denotes the peculiar ulcer, but rather the pus it secretes, and the poisoning it gives rise to. All other conditions vary; the secretion and its results alone remain identical. The primary sore, then, is endless in its character, being sometimes an excoriation so slight as hardly to attract the notice of the patient. Sometimes a pimple which itches, or a pustule containing pus, and which being broken incrusts, and under this incrustation is an eating ulcer, and this ulcer may take every character, from the superficial patchy excoriation to the deep wide-spreading phagedenic gangrenous ulcer destroying the entire organ. Many attempts have been made to arrange these different ulcers into species. The most practicable of these arrangements is into the venerola simplex, venerola superficialis, venerola indurata, and venerola phagedenica.

Of these the venerola simplex is the most usual form, and has this peculiarity; that at the time of granulation there is an elevation of the edge, and a rising up of the surface of the sore, which eventually becomes exalted like a fongus above the level of the surrounding parts, attaining its greatest height from the fourteenth to the eighteenth day, and on its cicatrizing leaving a permanent depression, resembling that left by the cow-pox or variola. The time required for healing this sore is generally from four to six weeks, and in general the disease runs its course so mildly, that except the glands in the groin enlarge, or the patient suffers from phymosis or paraphymosis, his general health is seldom impaired. The other forms of venerola may be inferred from their designation; and the reader is referred to the works of Mayo, Skey, Ricord, Hunter, &c., for a more particular description of their course.

The following table, from Boyer, *Pratique de la Syphilis*, 1836, is an approximation to the frequency with which different parts are attacked with primary syphilis:—

IN THE MALE.

| | |
|---|---|
| Fossa between the glans and prepuce | 269 |
| Orifice of prepuce | 154 |
| Frænum | 132 |
| Internal surface of prepuce | 127 |
| Surface of glans | 49 |
| Outer surface of the prepuce | 45 |
| Body of the penis | 41 |
| Orifice of the urethra | 11 |
| Scrotum | 5 |
| | 833 |

IN THE FEMALE.

| | |
|---|---|
| Fossa navicularis, or posterior commissure, and between this commissure and the vagina or fourchette | 41 |
| Internal surface of the nymphæ or petites lèvres | 37 |
| Meatus urinarius | 12 |
| Labia externa | 6 |
| Carunculæ myrtiformes | 5 |
| External surface of the nymphæ or petites lèvres | 3 |
| | 104 |

The *number* of primary ulcers is extremely variable, sometimes only one, frequently a plurality, as four, five, or six, while Boyer counted in one person sixteen, and in another twenty-four. In general they are more numerous in women than in men, the surface on which they usually form being more extensive. When there is a plurality of ulcers, they are often of very different characters, some presenting the Hunterian indurated base, while others are free from all hardness.

The *form* of the primary ulcer is more or less round, and its *size* is generally in the inverse ratio of the number, but this is not constant. The glans has often only one chancre, and this seldom exceeds the superficies of a sixpence, but occasionally it extends from the orifice of the urethra to the insertion of the prepuce. On the internal surface of the prepuce they are always large, those of the orifice generally round and small, while those of the external surface of the prepuce, of the body of the penis, and on the scrotum, are usually large. Boyer speaks of having seen them of the size of half-a-crown.

The duration of the primary ulcer is very various; for some ulcers, from which secondary symptoms will



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result, may heal in a few hours, while Ricord has inoculated from ulcers which have lasted eighteen months. The venerola simplex may heal in a few days, more commonly in about four to six weeks, the venerola iodurata in two to three months, while the venerola phagedenica, although it may destroy the part or the patient in a few days, yet, in any other case, is slow in healing.

The cicatrization of primary ulcers offers some differences. When they are superficial, they often heal and leave no trace; but in most cases they have an indelible and visible cicatrix. The Hunterian chancre leaves a deep cicatrix, but without any contraction or diminution of surrounding parts.

Primary ulcers often occasion, as concomitant circumstances, phymosis or paraphymosis, and that enlargement often followed by suppuration of the inguinal glands termed bubo. The duration of the bubo is very various; it seldom lasts less than from four to eight weeks, and often never entirely disappears.

The proportionate number of syphilitic persons suffering from bubo is one in seven, and from phymosis and paraphymosis one in two hundred and six; and it is calculated there are ten cases of phymosis to one of paraphymosis.

### Secondary Syphilis.

The secondary affections of the syphilitic poison embrace a greater variety of disease than results from the action of almost any other poison, as inflammation of the skin, of the throat, of the nose, of the bones, cartilages, and ligaments; also of the eye, and lastly, the formation of many adventitious warty growths.

It is the opinion of some pathologists, that the nature of the primary sore influences the nature, as well as the number, of the secondary symptoms. But every practitioner must have observed so many exceptions to this rule, the severest secondary symptoms sometimes following the slightest and most tractable primary sore; and, on the contrary, the most formidable primary sores being often followed by the mildest secondary symptoms, that the fact is far from established. If, however, we take the nature of the primary sore to be an indication of the constitution of the patient, we can easily understand why similar secondary symptoms may follow occasionally a similar primary sore, and thus form distinct groups or families.

*Cutaneous Affections.*—Of all the secondary symptoms the affections of the skin are the most remarkable, the same poison producing in different individuals almost every chronic variety of disease to which the skin is subject. There are, however, certain specific differences which distinguish the syphilitic from the ordinary affections of this tissue, which they simulate, as the shade of colour, which is of a deeper red or "copper colour;" also a tendency, on subsiding, to stain the natural pigment of the affected part with a dusky hepatic spot, of the same size and form as the original eruption—a discoloration which often long continues to disfigure the patient, together with a greater tendency to run into chronic ulceration. It is also a characteristic of syphilis, that two or three dissimilar eruptions may co-exist in the same patient, and likewise that they are seldom accompanied by itching.

The syphilitic eruptions admit of being classed under the orders papulæ, squamæ, exanthemata, pustulæ, vesiculæ, tubercula, and maculæ of Willan.

*Papulæ Syphiliticæ.*—The most usual forms of venereal papulæ are lichen, some forms of prurigo, and scabies. The species of lichen met with in syphilis are the lichen syphiliticus and the lichen syphiliticus agrius, or *scabby lichen.*

The *lichen syphiliticus* is an eruption consisting of a number of small, firm, solid elevations, or papulæ of the skin, which inflame and desquamate, leaving the inflamed part covered with a scurf; and among them may occasionally be seen papulæ, with acuminated vesicles containing lymph or pus. The colour of the lichenous spots varies from a pale red to a deep crimson, deadened by the exfoliation of the cuticle, which gives them an appearance of scaliness. As each lichenous spot declines, it leaves a brown or copper-coloured stain of the same size as the original affection, and which frequently lasts a considerable time. This variety often consists of a series of crops, and each crop is frequently ushered in with a smart attack of fever, which does not always subside on the appearance of the eruption. It is usually accompanied by pains in the limbs, which are most severe at night. The papulæ of this eruption are often very numerous, particularly on the face; also on the alæ of the nose, and the commissure of the lips, as also on the back, abdomen, and arms. This form seldom ulcerates, and is not accompanied by pruritus.

The time of the appearance of this eruption after infection is extremely uncertain; but Mr. Carmichael has observed it to occur in the fourth or fifth weeks. Its duration is extremely capricious; sometimes it will decline in a few days, while it may last many weeks or many months. It is distinguished from the ordinary forms of lichen by the papulæ being more numerous and more confluent, and by their running more frequently into small oval clusters, whose greatest diameter may equal that of a shilling; and also by their being separated from each other by interspaces covered with papulæ.

The *lichen syphiliticus agrius* differs from the preceding variety in the eruption appearing without fever, in its being of a brighter red or copper colour, and by discharging a thin fluid, which concretes into a scab; so that should the disease be neglected, the clusters have a tendency to ulcerate. The ulcerated papulæ are generally in large patches, sometimes exceeding two inches in diameter. The lichen syphiliticus is exceedingly common, but the lichen agrius is less so. They often co-exist with most of the syphilitic eruptions, as well as with many other of the secondary symptoms, as affections of the eye, of the bones, or of the throat.

The *prurigo syphilitica* is a less frequent form of cutaneous eruption than the lichen syphiliticus. It attacks principally the pudenda of both sexes, often spreads to the thighs, and discharges an acrimonious matter, which inflames and excoriates the parts over which it flows; or should the eruption occur in the folds of the limb, of the opposite parts with which it is in contact.

The *scabies syphilitica* is the third form of papular eruption, and greatly resembles the ordinary forms of scabies papuliformis, but it is in no degree vesicular, neither is it accompanied by pruritus. It principally attacks the arms, thighs, and trunk of the body, and may co-exist with every form of secondary syphilis.

*Squamæ Syphiliticæ.*—The squamous forms of syphilis are lepra syphilitica and psoriasis syphilitica.

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The syphilitic lepra appears in circular patches, which resemble those of the lepra nigricans in size and colour, but are not similarly incrusted. The harshness and dryness also of the skin, so remarkable in the common forms, do not occur in syphilitic lepra. Each patch originates from a small, hard, reddish protuberance, whose circumference gradually increases. The patches are generally distinct, and seldom exceed the size, says Willan, of a shilling, though sometimes they are much larger. They have a raised edge, the central part appearing a flat surface covered with thin white scales. The leprous form of syphilitic eruption takes place, like other venereal eruptions, at very different periods after infection in different cases. If no medicines are employed, it is said to terminate in venereal blotches.

This eruption may be generally diffused over the body, or it may be limited to one or more parts, as the scalp, neck, shoulders, or to the thighs, legs, and arms. When it forms in the gluteal fissure, on the scrotum, or any other part where two surfaces are in contact, the cuticle, instead of desquamating, is smooth, of a dull white or grey colour, and covered with an unctuous matter.

There are three kinds of psoriasis syphilitica, or the psoriasis syphilitica diffusa, the psoriasis syphilitica palmaris vel plantaris, and the psoriasis syphilitica guttata.

The *psoriasis Syphilitica diffusa* scarcely differs from the ordinary forms of this eruption, except in being something deeper in colour. Its most usual seat is the posterior portion of the fore arm, or the anterior portion of the leg or knee; but it may attack many other parts, as the forehead, breast, back of the neck, or pubis. It not unfrequently accompanies periostitis of the tibia or ulna.

The *psoriasis Syphilitica palmaris vel plantaris* is described by Rayer in the following terms:—"In the palms of the hands, and soles of the feet, syphilitic psoriasis is almost always distinct. It makes its appearance by a number of spots, from three or four lines in diameter, but little or not at all prominent, and of a yellowish colour very similar to that of the thick horny indurations of the cuticle, often seen in the palms of the hands. If, at this period of the disease, a portion of the whole of the epidermis be removed, a thin layer of a yellowish substance will frequently be found deposited between the surface of the cutis and the detached cuticle. Small lamellar scales are very regularly thrown off from the palmar surface of the hand, and sole of the foot, which almost always present a mixture of yellow, of red, of violet, and of copper-coloured spots, or blotches surrounded by an epidermic rim. The spots of syphilitic psoriasis are occasionally arranged in the form of a large ring, in the palm of the hand: at other times they present the appearance of a kind of arc of a circle, something like psoriasis gyrata."

When this eruption affects a fold of the skin, as between the toes, or the fingers, or the nates, or thighs, the skin is elevated into a soft flat or convex surface, at first moist and whitish, then excoriated and red, and at length ruptured into cracks, rhagades, or fissures. That part of the finger or toe on which the nail is placed is often attacked, when a separation of the nail follows, and the affection is now termed syphilitic onychia.

"If mercury be not employed," says Mr. Carmichael, "the eruption proceeds to ulceration in the following manner:—Each spot is covered with scales, or by scurf, which is thrown off and succeeded by another; and every succeeding scurf which is formed becomes thicker than the preceding, till at length it forms a crust, under which matter collects, and it becomes a true ulcer, in which state it spreads very slowly."

The *psoriasis Syphilitica guttata* may appear partially or generally on every part of the body, but it is principally on the extremities and on the scalp that it is most frequently seen. It appears in irregular round patches of two to four lines in diameter, more elevated at the centre than at the circumference, of a reddish colour, covered with one or more scales, which are readily detached, and on falling off leave a hard, dry, polished surface. Biet observes, it is always surrounded by a whitish edge, similar to that which marks the disc of a vesicle, but this is not constant.

The *psoriasis preputialis* appears in the form of deep chaps or cracks around the margin of the prepuce, which, like similar affections of the lip, are extremely irritable, and apt to bleed whenever any attempt is made at retraction, but which, from the loose cellular texture of the prepuce, are in this case generally much deeper. The discharge is generally of a glutinous nature, sometimes purulent if improperly treated; the healing process is often very tedious. This disease is apt to give rise to bubo, or enlargement of the inguinal glands.

*Exanthemata Syphilitica*.—The species of this genus, though very numerous when they arise from ordinary causes, yet in syphilis are chiefly limited to four kinds, or to the roseula syphilitica febrilis, the roseola syphilitica annularis, the roseola syphilitica diffusa, and to the purpura syphilitica.

The *Roseola Syphilitica febrilis* is an eruption which appears either on the face, chest, trunk, or extremities, and is not to be distinguished except by the previous history from the roseola simplex of Willan. It is preceded and accompanied by a sharp febrile attack, lasts about a week, and then terminates by desquamation.

The *Roseola Syphilitica annularis* consists of a number of patches, of a dirty pink or copper-colour, generally distinct, seldom more than half an inch in diameter, and very much resembling the eruption in measles. These patches, when minutely examined, appear to be formed by the aggregation of four or five slightly-coloured points or stigmata slightly prominent; and, as in measles, their colour is evanescent on pressure. They frequently cover nearly the whole of the body, but most principally affect the neck and scalp, the alæ of the nose, the commissure of the lips, and also the forehead. The arrangement of the patches on the forehead is sometimes peculiar, and forms one of the many corona veneris of this disease. This eruption is often tedious, most generally terminating in slight desquamation; but, like all syphilitic eruptions, has a tendency to ulcerate. On dying off it leaves a brown hepatic spot, that for many months continues to mark the form and seat of the original disease.

The *Roseola Syphilitica diffusa* is a diffuse inflammation of the skin, generally of considerable extent, and of a deep red colour. Its usual seat is the back and neck. This eruption frequently co-exists with tobercula syphilitica, and on dying away leaves no discoloration of the rete mucosum.

The syphilitic forms of purpura are, purpura syphilitica and purpura syphilitica hæmorrhagica. Their varieties are not dissimilar to the ordinary forms of purpura described by Bateman. The stigmata of the first variety are extremely minute, sometimes a mere point, not exceeding the bite of a flea. In the second, how-



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ever, they form large patches, sometimes as big as the palm of the hand. The arms, thighs, and trunk of the body are the principal seats of these forms of disease, which not unfrequently precede the squamous and pustular forms of syphilis, and often accompany the papular and tubercular eruptions. The erythemata syphilitica are rarely followed by iritis, but they are not unfrequently accompanied by some affection of the bones. They also often accompany the papular and tubercular eruptions.

*Pustulæ Syphiliticæ.*—The ecthyma syphilitica is the only known pustular form of syphilitic cutaneous disease.

The *Ecthyma Syphilitica* is an eruption of pustules about the size of a small-pox pustule, having a hard circular inflamed edge and base. The pustules are, therefore, phlyzaceous. Each is surrounded by a copper-coloured areola, which discharges a sanious matter, which scabs, and on healing leaves a deep cup-like cicatrix, which is permanent. They form principally on the forehead, alæ of the nose, and beard; and as they have a tendency to become confluent, often produce a most unsightly corona veneris. This disease is at all times chronic, and if neglected is said to push forth fungoid vegetations.

Rayer has given a form of ecthyma syphilitica, in which the pustules are psydracious, and consist of minute pustules irregularly circumscribed, slighly eminent, and forming a scab. He represents them as numerous, often confluent, and on rupturing as discharging a thin watery humor, which forms an irregular incrustation. A case of this rare kind was a short time ago in St. Thomas's Hospital, in which the eruption appeared first on the legs, where it left many large rupia like sores, and subsequently a tolerably large crop appeared in the neck.

*Vesiculæ Syphiliticæ.*—It is doubtful whether any form of this genus exists, except rupia and herpes preputialis.

The *Rupia Syphilitica* consists of a number of dusky brown tumors of considerable size, each of which is surmounted by a vesicle, which breaks and discharges a clear transparent glutinous fluid that concretes into a scab, having a peculiar conoidal form resembling a limpet shell, in consequence of each successive formation being larger than the one that preceded it. Beneath this remarkable incrustation, however, a slow process of ulceration goes on, so that on the scab falling off a wide-spreading ulcer is seen, sometimes superficial, but at others deep and foul. In the latter case it occasionally penetrates to the tibia, the ulna, the clavicle, or to the bones of the nose, or of the cranium, causing ulceration and caries of those parts. This ulcer heals from the edge, and when completely healed the cuticle, according to Rayer, repeatedly desquamates, a result, however, by no means constant. On healing, the ulcer leaves a permanent cicatrix.

This disease usually appears on the legs and thighs, or on the arms or back. The face and scalp are also often its seat, as also every part of the nose, eyebrow, and even the inner eyelid, and it may form on every other part of the body. The number of these tumors is seldom great, often not more than two or three, and seldom more than twenty. In size they generally vary from a small nut to a walnut. Their duration depends, in a great measure, on the treatment; for if left to themselves, they often continue open sores for many months.

The most remarkable circumstance connected with rupia is the extreme depression of the constitution which accompanies it; for many strong, and even robust, persons become greatly worn, and even emaciated, under its influence, and in a degree by no means accounted for by the extent of the ulceration. In many instances this disease has proved fatal.

The herpes preputialis first appears as a cluster of vesicles which scab, and this being removed, a number of small circular ulcers is seen, with a yellow or white surface, often running into one another, with an edge sometimes a little raised, and of which the healing process is sometimes tedious.

*Tubercula Syphilitica.*—The term tubercle, in dermatology, does not imply that peculiar substance which bears that name when deposited in the lungs, but is defined to be a small, hard, superficial, isolated tumor, or elevation of the skin, resembling a wart in character, ordinarily isolated, but sometimes confluent, and whose natural course is to terminate in slow ulceration. Of tubercula syphilitica there are two varieties, or tubercula syphilitica rubra, and tubercula syphilitica flava, and these may be either round or flat.

The *Tubercula Syphilitica rubra rotunda* consists of a number of firm, solid, moveable tumors, of a conoidal form, and about the size of a split pea, *red*, not painful, nor the seat of pruritus. They are usually very numerous, and appear sometimes on the face, but more commonly on the trunk of the body, and especially over the back and shoulders. This disease often assumes a particular form, and sometimes, if neglected, ulcerates. Its duration is very various, and though it may terminate in a few weeks, it usually lasts two, three, or four months, or longer.

The *Tubercula Syphilitica rubra plana* consists of a number of flat tubercles, having an equal thickness over their whole surface, except at the edge, where it is in more prominent relief by a line or more. Their colour is of a livid red, and their size varies from a lentil to the palm of the hand. This variety has a great tendency to ulcerate, and then the edge thickens and rises, so that the body of the tubercle generally appears depressed. The swollen surface becomes fissured and secretes a faint dirty white matter. These fissures sometimes increase to considerable ulcers, and on healing their cicatrices at first resemble yellowish or violet-coloured blotches, and do not acquire a natural colour or proper pliancy, until after a very long period. It is remarkable also to observe these ulcers, as in cancer, healing in one direction and spreading in another. They are attended with little or no pain, and with little inflammation beyond their edges, which are deep and sharply cut. Sometimes, however, they assume a phagedenic character, so that when they attack the face they do not present regular cicatrices, but unsightly bands, or rather seams, as after severe burns, or in the lupus exedens.

The duration of the flattened form is always exceedingly chronic, and when ulcerated the process of healing is extremely slow. Its principal seat is the pudendal region, as the labia majora, glans, or scrotum; sometimes they form round the anal aperture, and their fissures may then penetrate the rectum. More commonly, however, they form on the inner part of the thighs, the groin, and over the gluteal muscles, or on the trunk; they are also occasionally seen on the face, lips, and ears.

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Elementary Principles of Medicine.

The *Tubercula Syphilitica flava, vel rotunda vel plana*, does not differ from the red variety, either in seat, form, duration, or termination, or in any other respect than the tubercle preserving the colour of the skin. Sometimes, however, these pass into the red state.

Among the tubercula must be classed those many vegetations, excrescences, or warts which are so frequent in syphilitic patients.

These vegetations are developed in two different manners, each influencing the form they afterwards take. In the one the vegetation first appears about the size of a large pin's head, and is most commonly white, but in some few instances red, and we feel on the surface inequalities, as in a strawberry. The vegetation increases till it is termed cauliflower, cockscomb, or, when springing from distinct sources, asparagus, or other familiar name.

This species also includes all those varieties which have been classed under the heads of rhagades, fici, condylomata, &c. It also includes those hypertrophied and elongated labia or nymphæ, which are often of monstrous growth, and hang pendent for many inches. In general they grow from those parts which were the seat of the primary sore. These growths are most common in the female.

*Maculæ Syphiliticæ.*—Maculæ syphiliticæ are partial discolorations of the skin, forming patches which vary from a sixpence to the size of the open hand. They are either of a yellow or brown copper colour, and appear to depend on an alteration of the pigment of the rete mucosum. In general the maculæ terminate without any other sensible alteration than of the colour of the skin. But in a case lately in St. Thomas's Hospital these patches exhibited the remarkable phenomenon of ulceration under the cuticle. The ulcer thus formed had a sharp edge, as though made by a punch, and its base was about two lines below the surface of the skin in every part. It was covered by the cuticle, not detached, but puckered up, so as to lie loosely upon it, and presented a most beautiful specimen of the dry ulceration of Mr. Hunter. The maculæ form principally on the trunk, frequently covering a large space, and often on the face and extremities. The duration of this form of cutaneous eruption is always extremely long, and may last many months or even years.

*Of the Syphilitic Diseases of the Osseous System.*—Next to the dermoid tissue, the osseous system is the most frequent seat of the secondary action of the syphilitic poison, and its diseases are important, as they are frequently of long continuance, often disfigure the patient, and are in most instances the cause of severe suffering. Some pathologists, in an excess of scepticism, have doubted the action of the syphilitic poison on the bones, but the public have entertained no such difficulty; and the poet whose Court of Death we have before quoted, embodies this doctrine in the following lines:—

> "A haggard spectre from the crew
> Crawls forth, and thus asserts his due:—
> 'Tis I who taint the sweetest joy,
> And in the shape of love destroy;
> My shanks, sunk eyes, and noseless face
> Prove my pretensions to the place.'"

The principal syphilitic affections of this system are inflammation of the periosteum, and inflammation with enlargement, ulceration, abscess, or necrosis of the bones themselves. It is remarkable that these affections differ in many important circumstances, according as they occur in the flat or in the long bones.

The periosteum of the long bones is subject to syphilitic inflammation, which probably often extends to the bone itself. The result of this inflammation is thickening of the periosteal membrane, and the deposition of a hard membraniform substance on the surface of the bone, and which, if recent, may be removed by maceration. This newly-formed part is termed "*a node*," and it may be absorbed, may ossify, or may ulcerate. The termination by absorption, however, is seldom seen, unless the disease be recent, and the patient early submitted to medical treatment. The termination by ossification was formerly the most frequent, and in this case points of ossific matter are first deposited throughout the membranous substance of the node, which gradually multiply until they form a bony mass, or tumor of greater or less size and solidity attached to, and at length forming an integral part of the bone. The node thus ossified is, under the most favourable circumstances, only slowly absorbed, and many years may perhaps pass away without any great reduction, during which the patient is liable to continual relapses.

The hard periosteal node, whether membraniform or ossified, formerly often terminated by suppuration; the pus effused forming a superficial, fluctuating abscess, surrounded by the sharp edge of a deep cup-like ulcer. The pus thus formed may be absorbed, and the abscess heal, or else it may burst, or make its way to the surface, and in the latter case the bone may be exposed, or so affected that it may exfoliate.

The periosteal node just described does not attack all the long bones equally, never attacking the phalanges of the fingers, or the bones of the feet, but has its seat almost exclusively on the bones of the leg, of the fore arm, and of the clavicle. Neither does it attack all these bones with equal frequency, for the hard node exists much more commonly on the tibia than on the fibula, and on the ulna than on the radius, while the clavicle is only occasionally the seat of this affection. When the tibia is affected the centre of the shaft of the bone is more commonly the part diseased, then the lower third, and more rarely the upper third of the bone, and both tibia are more commonly affected than one. When the ulna is affected, it is the upper third on which the node more usually forms, and one ulna is more usually diseased than both. It is doubtful whether the femur or the os brachii is subjected to this form of node, although it seems proved that their shafts are occasionally the seat of syphilitic inflammation.

The long bones also are sometimes the seat of a disease termed "the soft node," or more popularly the "gummy node." This disease consists equally with the former, of an inflammation of the periosteum; but according to Desruelles, of its external surface, and also of the intercellular tissue of the muscles, and of the ligaments terminating in the secretion of a fluid of the consistency of gum water, of a thin jelly, or of still greater firmness. This form of node is of so rare occurrence, that it is doubtful whether it has been rightly attributed to a syphilitic origin. It is attended with less pain than the hard node, except it presses on a nerve, when every motion of the limb is excruciating. It is usually indolent, but has a tendency at last to ulcerate, sometimes extensively and deeply, so that not only exfoliation but death has followed. The tumor is generally moveable, and the skin, unless near bursting, of its natural colour. Its usual seat is either the fore arm, the leg, or the head. This node is of difficult cure, and its duration indefinite. Its fluid contents require to be analyzed.

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The syphilitic poison may also cause inflammation of the substance of the long bones, especially of the thigh bones and the phalanges of the fingers, terminating in enlargement, in ulceration, in abscess, in caries, or in necrosis of those parts.

The periosteum of the cranial bones is often affected in syphilis, but the node now formed follows, to that of the long bones, entirely different laws. When the syphilitic poison produces nodes on the cranium, we might be led to imagine, from the external appearance, and from the firmness and resistance of the node, that it was of exactly similar formation to that of the tibia and ulna, and that a membraniform substance, ossified or otherwise, was deposited on the bone. But on a careful examination of many syphilitic crania, no membrane or ossific matter has been found in the node, so that it is probable that the hard, immoveable, external cranial node is caused by an infiltration of the soft parts, bound down by their peculiar aponeurosis. Even in those strangely worm-eaten skulls in which deposition and absorption, thickening and thinning, newly-formed parts and immense voids, are so singularly intermixed, no membraniform or ossified substance, similar to that of the tibial node, is to be seen. This node much more frequently suppurates and ulcerates than the nodes of the long bones. Its more usual seat is the frontal and parietal bones, and there is seldom more than one or two, or at most three.

If the disease proceeds the bone itself is affected, and ulceration and extensive exfoliation of the outer table often takes place, and the disease sometimes spreads, even to the inner table, exposing the membranes of the brain. A portion of the cranial bones being destroyed, pathologists are not agreed in what manner the injury is repaired; but the more common opinion is that the void is first covered with soft parts, and then that a slow process of ossification goes on, so slow that a long period elapses before the defective part is repaired by ossific deposit.

The syphilitic poison may also fall on the bones of the face; and we have many specimens in our museums, in which the ossa malarum and the bones of the orbit are extensively eroded from ulceration. But syphilis is now so easily and so completely checked by medicine, that any affection of these bones is extremely rare.

The bones, however, of the nose and palate are still found to be frequently diseased. In these cases the affection may begin by inflammation and ulceration of the mucous membrane, but more commonly perhaps the disease is seated in the bones themselves. This inflammation, in whatever manner set up, usually terminates in necrosis, sometimes so extensive that the vomer, the ossa unguis, the turbinated bones, or a considerable portion of them, exfoliate. The cartilages, as well as the bones of the nose, are also frequently involved in the disease, so that the hard parts being thus withdrawn the soft parts fall in and produce a permanent and most unsightly deformity. Thus the alæ of the nose may alone be destroyed, or else the whole of the proper bones may exfoliate, and the soft parts sinking, nothing but the mere tip of a nose is to be seen.

It is seldom that the bones of the nose are affected in any considerable degree without the palate-bones ulcerating, and also exfoliating to a greater or less degree. In this latter case it is the superior maxillary bone, and not the palatine bone, which forms only the posterior fifth of the palatine arch which is affected, and usually the middle of the horizontal portion of it, or only in a few instances posteriorly towards its union with the palatine bone. At other times, but more rarely, the anterior portion of the superior maxillary bone, and which contains the alveolar processes of the incisor teeth, is its peculiar seat. It is generally, but not constantly, the suture which unites the two superior maxillary bones which is the part attacked, and more frequently one bone affected than both. The exfoliation of the necrosed portion always leaves an incurable perforation, unless it be extremely small indeed.

In general the periosteal affections of the cranium and of the long bones occur from a few weeks to three or four years after contamination, and are accompanied by a degree of pain and tenderness almost amounting to agony, and in a short time greatly reduce the patient. On the contrary, however, the affections of the nasal and palatine bones, even when the devastation is excessive, are seldom accompanied by severe pain. In affections of the nose most commonly the patient's attention is first awakened by a swelling and uneasiness of the parts rather than by pain. These symptoms are followed by a discharge from the nostrils, at first small in quantity, serous and inodorous, which often concretes into a thick and troublesome scab. As the disease, however, advances the discharge becomes purulent, mixed with blood, and when the bone is necrosed sometimes insupportably fœtid. In this state the disease is termed ozena or ozæna. There are cases in which the mucous membrane is so entirely removed that we can see the denuded bone, while we can almost always detect it by the probe.

When the palate-bones are diseased the discharge from the mouth is seldom considerable, except in a few instances, when the quantity from the antrum is distressingly large. The soft parts at length ulcerate, and exfoliation of a part of the arch follows. When exfoliation has taken place there is always an aperture by which air, and also liquids, can pass from the mouth into the nose. As long as the aperture is small the consequences are rather disagreeable than inconvenient; but when large the voice is altogether changed, and the patient speaks through his nose. Deglutition is also difficult, because the aliment can no longer be pressed against the palatine arch without passing wholly or partially into the nasal cavities. Another inconvenience likewise results, or the occasional discharge of the nasal mucosities into the mouth. The duration of the syphilitic affections either of the nasal or palatine bones, if left to nature or improperly treated, lasts for many months, and only terminates after great destruction of parts. Under a judicious treatment a cure is generally effected in a few weeks, and without disfiguration.

The cartilages, especially those of the sternum, are the occasional seat of the secondary affections of the syphilitic poison. The opportunities, however, of examining these parts are few, since the disease in almost every instance is cured; but the symptoms are those of inflammation, with great thickening, except in some few cases when ulceration and perhaps necrosis follow.

The fibrous capsules and the ligaments which surround and unite the articulations of the larger joints are often attacked, and form a large amount of the cases of secondary syphilis. These affections may be either acute or chronic, and do not essentially differ from those of acute or chronic rheumatism. Boyer states that articular dropsy is a common result, and which terminates in an impossibility of extending the

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affected limb. Inflammation of the interior of a joint, especially of the elbow-joint, is by no means unfrequent. Pains simulating rheumatic pains, and enlargement of the joints of the finger, as in gout, are likewise common. The duration of this class of affections is often long, and the treatment unsatisfactory.

*Of Syphilitic Diseases of the Throat.*—The parts next in frequency of attack and severity of symptoms after the cutaneous and osseous systems are those of the throat, which may be divided into angina syphilitica mitior and into angina syphilitica gravior.

The *angina syphilitica mitior* has many grades. It may be limited to a slight blush of inflammation, which may resolve, and the disease be at an end; or it may be characterized by an exceedingly hard and enlarged state of the tonsils, whose superficies is covered by patches of a viscid mucus or lymph, and at a subsequent stage by a number of small superficial ulcers. In other cases the tonsil is much less swollen, and a small chronic ulcer forms on it, sometimes of no great depth, while at others there is a fair loss of substance. Again, another form of syphilitic sore throat is when the parts are little swollen, but a superficial ulcer with a distinct edge spreads far and wide, healing in some parts and spreading in others, after the manner of a superficial phagedenic ulcer. This description of ulcer is often of long duration and difficult of cure.

The *angina syphilitica gravior* is characterized by no very considerable enlargement of the tonsils, but the inflammation is usually extensive, embracing the tonsils, velum palati, the uvula, and very commonly the pharynx. The inflammation is also much more asthenic, and usually begins by a diffuse redness of the mucous membrane of the throat generally, and in a few hours a foul and deep ulcer forms on each tonsil, having a broken-down irregular edge and a base covered with a dirty ash-coloured slough, the whole surrounded by a deep-coloured erysipelatously inflamed margin. The ulceration of the velum palati may begin either on the anterior or posterior surface of that membrane: in the latter case, if the disease be rapid, the velum may be destroyed almost before the disease is discovered, or even suspected to exist.

The uvula also is usually attacked at its base, generally at the posterior part, where an eating ulcer forms, and so rapid in its course that the uvula is constantly seen hanging in the fauces by a mere shred, so that the least delay in the administration of proper remedies is often followed by the entire loss of that part. Indeed, in the greater number of cases it is already detached before the patient is admitted into the hospital. From the tonsils and soft palate the inflammation may spread to the arch of the palate, or up the nasal fossæ, and thus lay the foundation of the destruction of the nasal and palatine bones.

The most appalling symptom, however, is when the inflammation extends to the pharynx. In this case the ulceration may be so situated as to be hid by the velum or by the root of the tongue, and, thus concealed, may make extensive ravages before it is discovered. More commonly, however, a single ulcer forms in the central and visible part of the pharynx, having an irregular broken-down edge, a dirty base, and surrounded, as in the former case, by a wide extent of angry erysipelatous inflammation. This frightful ulcer sometimes continues to spread as far as the eye can reach, so that the whole back of the pharynx is often one universal foul sore, sometimes penetrating so deeply that the spinal bones may be both seen and felt.

From the pharynx the inflammation may extend to the Eustachian tube, and the patient be rendered either temporarily or permanently deaf. Occasionally it involves the glottis, epiglottis, and even the larynx: when the larynx is affected the symptoms are, difficulty of breathing, with the stridulous whispering voice of croup, constant cough, and copious expectoration. The epiglottis has also been known to slough off, and then the patient can only swallow by holding his nose. Mr. Carmichael gives two cases of sudden death in the Lock Hospital from foreign bodies under these circumstances slipping into the trachea; and Mr. Mayo another, in which the patient died of ulceration of the lingual artery with hæmorrhage, notwithstanding a ligature was applied round the common carotid. When this pharyngeal disease terminates favourably a cicatrix forms, much whiter than the mucous membrane, striated and banded in every direction; and as it has less vitality than the membrane for which it is a substitute, it is liable to frequent but slight relapses. If the patient falls the throat becomes dry and brown, the pulse rapid, great restlessness supervenes, the legs swell, and the patient dies with the worst symptoms of hectic or continued fever.

Syphilitic angina is rarely accompanied by fever in the early stages, and this is the great diagnostic symptom which distinguishes it from the ordinary forms of sore throat, for it is needless to say that the copper colour of the inflammation attributed to it by some writers never exists. If left to itself, syphilitic angina is of almost endless duration, and sometimes of fatal termination. It often co-exists with every other secondary symptom.

*Of the Syphilitic Diseases of the Eye.*—The eye is less frequently affected by the syphilitic poison than the skin, the bones, or the throat, but still inflammation of this organ is by no means unusual, and its principal seats are the conjunctiva, the transparent cornea, the iris, and, judging from the degree in which the eye is pained by light, the retina, and perhaps also the entire globe of the eye.

Syphilitic inflammation of the *conjunctiva* may exist *per se*, or it may be conjoined with iritis, and the latter is much the most frequent. Its pathological character is diffuse inflammation, of greater or less extent, of the conjunctiva, varying from an arborescent state of the vessels to a general congestion, changing the brilliant white of this membrane to a livid red. Immediately around the cornea is a zone of still deeper intensity, which strikingly contrasts with that transparent tissue.

The *transparent cornea*, though nourished by vessels carrying transparent colourless fluids, is nevertheless susceptible of high inflammation. This inflammation occasionally exists *per se*, and may terminate by effusion of lymph or by ulceration. When lymph is effused it is poured into the lamellated structure, so that the eye is dull and the cornea nebulous or opaque; and if it be deposited generally over the pupillary portion, the membrane becomes impenetrable to light, and blindness is the consequence. If the disease proceeds, red vessels are seen to shoot into the effused lymph, and the superficies of the cornea frequently ulcerates.

The most remarkable affection, however, in syphilitic ophthalmia is *iritis*, which usually accompanies the preceding forms of the disease, and its termination may be

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by resolution, the throwing out of lymph, or by the effusion of pus. In general the syphilitic inflammation attacks the posterior rather than the anterior surface of the iridial membrane, which becomes thickened, the pupil contracted, and often so diminished as scarcely to exceed the size of a pin's head. The iris thus contracted generally forms adhesions more or less partial, so that the pupillar edge appears puckered, irregular, and, instead of a circular, often takes a polygonal shape, with three or more sides. The inflammation, however, is rarely confined to the posterior, but very constantly involves the anterior surface of the iris. "In this case," says Mr. Lawrence, "the iris loses its brilliancy, appears dull and dark, and the beautiful fibrous arrangement which characterizes it in its healthy state is either confused or entirely lost; a light-coloured iris assumes a yellowish or greenish tint, a dark-coloured iris a reddish brown." Vessels carrying red blood are also now seen radiating on the outer surface, often depositing lymph of a reddish brown or ochre colour, or tinged with blood in various manners, and occasionally in such quantities as to hang pendulous in the outer chamber of the eye, or else to thrust the iris forward by its accumulation in the posterior chamber of the aqueous humour. If the inflammation proceed, this may become organized, and present a permanent obstacle to the transmission of light, or the capsules of the lens may be thickened and rendered so opaque that the patient may become temporarily or irrecoverably blind. The disease may proceed to still further destruction of parts, but in general it is early subdued by medicine, when it usually terminates by resolution, and before any irremediable alteration of structure has taken place. In this case the red vessels disappear, the effused lymph is absorbed, and the adhesions being recent and slight are readily broken down, and the patient ultimately recovers the perfect use of the organ. But its powers are often for a time impaired, so that vision is either confused or weak; neither does the pigment of the eye immediately resume its colour, but is so changed that a hazel eye is turned to grey, and a black eye to a green one, and the patient after his recovery has perhaps one eye of one colour and the other eye of another colour, and neither of them the natural colour—an unsightliness which may last for a considerable time.

Inflammation of the cornea or of the conjunctiva is rarely accompanied by severe pain, but more commonly by soreness; a sensation of dryness; great weakness of sight, and by an increased lachrymal discharge. Iritis, on the contrary, is usually attended by severe, agonizing, deep-seated pain, and by intolerance of light. There are, however, a few instances in which the pain is trifling, and the sight merely weak. Syphilitic Ophthalmia is in general double, but in a few instances is limited to one eye. The duration of the various forms is usually short, as they readily yield to a mercurial treatment. In general, iritis is preceded by one or more of the secondary symptoms, and most commonly is that affection which terminates the disease. It is said to be more frequent in women than in men, but this proposition is not established.

*Treatment.*—The cure of the primary ulcer has never been esteemed one of the great difficulties in the treatment of syphilis, for at all times, it has been observed often to yield to very trifling remedies; very generally to greater or less doses of mercury, and only in a few instances assuming an intractable or phagedenic form. In practice, however, this problem has been rendered one of the most intricate in medicine, from the various theories which have been connected with it. Some, for example, have considered the primary ulcer to be at first a local disease, and that the poison which contaminates the constitution is secreted by it, and consequently that early cauterization would prevent the occurrence of all the secondary symptoms; others again have held that mercury was essential to the cure of the primary symptoms, for without it they would not heal, and therefore that the system must to a certain extent be saturated with that metal; while others, again, have affirmed that medicine not only to be a remedy for the primary form of the disease, but also a specific antidote against the poison of syphilis, so that a given quantity was an infallible prophylactic against all the secondary symptoms, as well as a cure for them in every stage. These hypotheses, however, are altogether unsound, or in contradiction to all we know of the laws of morbid poisons—for mercury has been often proved not to be essential to the cure of the primary symptoms; neither is the poison secreted by the primary sore that which contaminates the constitution, so that cauterization will not cure the disease. Again, mercury is not a prophylactic against the secondary symptoms, for no quantity, however large, will prevent their recurrence, although it must be admitted that that medicine is often a remedy of great value in their cure. It follows then, from these considerations, that the rule of treatment in syphilis is to heal the primary sore as rapidly as possible, and to employ for that purpose the simplest and least injurious means in our power; and in this manner we effect not only the greatest present good, but also afford the patient the greatest number of chances of escape from an attack of the secondary symptoms. Again, should any secondary symptoms arise, we should treat it on the same simple principles as the surest prophylactic against any further number of the series; and consequently we thus greatly mitigate the sufferings of the patient, as well as shorten the whole duration of the disease.

Applying these principles, we find that a large proportion of the *unindurated* primary sores treated in the army, have been healed without mercury, except perhaps some mercurial wash or local application; and principally by confining the patient to his bed, or else to the wards of the hospital; and also to a spoon diet. The remedies employed in addition have been extremely simple, or occasionally general bleedings (as in six or eight cases out of 1940), purgatives, antimonials, emollients, soothing applications, generally cold or warm water mixed with the liquor plumbi; and in the latter stages by the application to the part of the lotio hydrargyri submuriatis or muriatis in aqua calcis, or else the lotio cupri sulphatis vel argenti nitratis, or other similar means.

In civil life, the same results have been obtained where the same means have been employed; but it is rare that the time necessary for the cure to take place can be commanded, and most writers recommend that the unindurated sore should be treated at first as a simple ulceration, or by cleanliness, by abstinence, and by applying to it the most mild and simple dressings; and many ulcers that will be followed by secondary symptoms will heal under this simple treatment. If the ulcer does not put on a healing appearance after a reasonable time, the patient should make use of more active dressings, as

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the black wash; and should these be ineffectual, and the sore still remain open, a mild and judicious administration of mercury should be had recourse to till the sore is healed. In most cases, the pil. hydrargyri, gr. v. twice or thrice a day, is sufficient, and the success of Mr. Abernethy has proved that a large majority of primary ulcers will heal under this treatment.

In addition to the above remedies many practitioners recommend the application of lunar caustic to the sore, whatever may be the stage of the disease, as a means by which the process of cicatrization is greatly assisted. Mr. Carmichael, however, limits the time to the first stage, and before pus has formed. Ricord also tells us to abstain from using caustic to the part while it is yet granulating, and to confine its employment to points still in a state of ulceration—discrepancies which show that the practice is anything but determined.

The superficial venereal ulcer or excoriation "is the most easily cured by any mild astringent lotion injected five or six times daily between the glans and the prepuce, or the yellow mercurial lotion, or the weak solution of lead, or of the sulphate of zinc."

The indurated ulcer, like every other form of primary syphilis, has been successfully treated without mercury.

But it does not by any means follow that the non-mercurial is the most judicious mode of treatment. Indeed, almost all British writers are agreed that recovery under that method has been remarkably slow, while, if mercury has been exhibited, the healing of the sore has been certain and rapid. Ricord also states, that although the exhibition of mercury for unindurated ulcer is often more hurtful than beneficial, yet the circumstance of induration immediately transforms it into a therapeutic means of great power. In the treatment of the Hunterian sore, therefore, nothing is doubtful or perplexing; the rule being by mercury, and the exceptions only those cases where its use is forbidden by a debilitated or scrofulous diathesis, or by other peculiarity of constitution. The manner of introducing mercury into the system must be left in a great measure to the discretion of the practitioner. If the case be slight, five grains of the pilulæ hydrargyri twice or thrice a day is sufficient. It is more common, perhaps, when the case is well marked, to rub in half a drachm or a drachm of strong mercurial ointment every night, and this quantity is generally sufficient to touch the mouth in six or eight days, and to produce a considerable soreness at the end of twelve days; and shortly afterwards the ulcer heals.

When the ulcer has cicatrized, and the tissues which have been its seat have recovered their healthy state, the disease is cured. Sometimes, however, an induration remains, and in this case the cicatrix often ruptures, and relapses are the consequence. Under these circumstances, we should be cautious not to lay aside the use of the ointment too soon, and the patient should rub the part twice a day with mercurial or iodine ointment; a practice often successful when the indurated portion is situated on the skin, but not so commonly when on the mucous membrane. Delpech and many other surgeons have recommended excision, and this operation has succeeded, but more commonly has been followed by a renewal of the disease, so that it ought not to be employed except when the cicatrix is small, or of a cartilaginous hardness, and moveable in the subjacent cellular tissue. The resolution of this induration is, however, always tedious.

With respect to local treatment in the indurated ulcer, Beaumés states that it is not so advantageous as in the unindurated ulcer, and is favourable in proportion as the induration is dissipated by a mercurial treatment. All are agreed that fatty substances are ordinarily hurtful in the treatment of the indurated primary sore, and especially mercurial ointments. Many authorities also recommend cauterization in this form of ulcer, but this practice cannot be received as universal; and Ricord admits when the induration is even of little extent, cauterization is much less efficacious than under other circumstances.

*Treatment of Venerola Phagedenica.*—Ricord divides this description of ulcer into three kinds, or the indurated phagedenic ulcer, the phagedenic gangrenous ulcer from excess of inflammation, and the phagedenic gangrenous ulcer from debility or constitutional tendency.

The induration of a venereal sore or part may so increase as not only to oppose the formation of a cicatrix, but also to make such compression as to produce gangrene. In this form of the disease he recommends a concentrated solution of opium, emollient cataplasms, and antiphlogistic remedies. When the ulcer is of little extent, cauterization with the argentum nitratum, though not greatly successful, is still useful, and often stops the progress of the gangrene and represses those exuberant vegetations that have a tendency to become fungoid, and, much as mercury is hurtful in the other forms, by so much the more it is advantageous in this.

In the treatment of the gangrenous sore by excess of inflammation, he tells us we must forget the specific nature of the malady, and treat it merely with reference to this excess of inflammation. How many accidents, says this eminent authority, have we not seen from an empirical mercurial treatment directed against the specific cause! Dr. Collis also states, that throwing in mercury largely and suddenly was, in many cases, not successful.

The *Phagedenic Gangrenous Ulcer* from debility or constitutional idiosyncrasy is a form of disease most usually contracted in hot climates, and makes such havoc when the patient returns to the north, and is termed the "black lion." It is also sometimes contracted by persons living in low and damp situations, and is often suddenly and happily changed by transferring the patient to the wards of a well ventilated and well situated hospital. "In this form of gangrene," says Ricord, "it is a very great error to fly to the use of mercury. I can affirm, with very few exceptions, that nothing can be worse than mercurial dressings and mercury exhibited in this form of disease;" and he recommends repeated cauterization and an application of aromatic wine; and in severe cases, he sprinkles the part with powdered lytta and the "*pâte de Vienne*," which daily experience, he adds, authorizes him to recommend.

*Treatment of Phymosis and of Paraphymosis.*—Phymosis and paraphymosis are much less frequent attendants on indurated than upon unindurated sores; but whenever a disposition to phymosis or paraphymosis occurs, the patient should be strictly confined to the recumbent position, and in the former case be desired to inject warm water frequently between the glans and the prepuce. Poultices of bread and water may also be applied with advantage, and antimony given in such doses as may excite slight nausea. These means are often sufficient, but when the inflammation is violent, the penis considerably swollen, and attended with acute



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pain, if the most active measures are not adopted, the inflamed parts will fall into a state of mortification. "In these cases," says Mr. Carmichael, "the symptomatic fever may run so high that the pulse is from 110 to 130, with thirst and restlessness; under such circumstances I immediately direct blood to be taken from the arm in proportion to the urgency of the symptoms and health of the patient, and repeat venesection every six to eight hours until the inflammation begins to yield. It is as necessary to have recourse to the lancet in these cases as in pleurisy or the most acute ophthalmia. However beneficial *local blood-letting* may be in inflammation of other parts, it is scarcely admissible in this; for if the matter which flows from beneath the prepuce should come in contact with the wounds, troublesome sores might follow, which might still further add to the inflammation it was intended to subdue. By active measures of this kind, if employed in time, we shall avert the worst result, a mortification of the prepuce, or suppuration of the body of the penis under its investing ligaments." In the phagedenic form of this affection the danger is imminent, and the best surgical advice should be had recourse to, and the division of the prepuce, if recommended, be immediately submitted to. In the

*Treatment of enlarged inguinal glands, termed "Syphilitic Bubo,"* Mr. Carmichael has not found from experience that mercurial frictions will discuss them. On the contrary, the trials he has made incline him to believe that this medicine rather tends to increase their inflammation and consequently their tendency to suppurate. The application, however, of leeches and cold lotions, with attention to rest and quietness, he says, will often succeed in discussing them. When the bubo is hard and indolent, showing neither a disposition to disperse or to suppurate, he recommends the application of blisters to the indurated bubo, which soon either causes the dispersion or the suppuration of the tumor, and thus frees the patient from a troublesome symptom which might otherwise continue many months to torment him. If suppuration takes place, and the syphilitic bubo has broken, and the sore has a callous feel, and is either of a dark foul appearance, or of a light brown tawny colour, and this ulcer spreads, he says we may, with confidence, have recourse to mercury; and we shall in most instances find that quick amendment follows its exhibition. In general, also, after matter has formed, small doses of pil. hydrargyri have been found useful. The iodide of potassium has been strongly recommended in all forms of bubo by many foreign writers, but that medicine has not supported in this country the reputation it has acquired on the continent for the cure of that affection.

*Treatment of the Secondary Symptoms.*

If the problem of the treatment of the primary symptoms be difficult, that of the treatment of the secondary symptoms is still more so; for it is a law of morbid poisons that their secondary affections do not necessarily yield to the same remedies as their primary phenomena. It is plain, therefore, that mercury, the great agent in the cure of the primary symptoms of syphilis, is not necessarily efficacious in the cure of the secondary symptoms. In the treatment, therefore, of the secondary symptoms the early practitioners exhausted the whole pharmacopœia; and the modern French still employ a vast variety of remedies, so much so that Jourdan has dedicated a whole volume to their consideration; and even the formulæ of Desruelles, one of the last published works on syphilis, embrace no less than sixteen pages. The English school of medicine, however, has not been able to discover the beneficial effects of any other medicines in the cure of these forms of the disease than mercury, sarsaparilla, and, very recently, the iodide of potassium; the latter remedy, according to Drs. Watson, Clendenning, and others, having been first recommended for the treatment of this class of disease by Dr. Williams, of St. Thomas's Hospital.

*Treatment of the Syphilitic Diseases of the Skin.*—When the syphilitic poison falls on the skin, the many different diseases it excites require many different remedies and modes of treatment. In the course, then, of this class of affections we are obliged to employ all the three agents that have been mentioned, or mercury, sarsaparilla, and the iodide of potassium; and even these are not, in all cases, efficient.

Of all the syphilitic papular eruptions, the *lichen syphiliticus simplex* is the most intractable by medicine. The iodide of potassium does not appear to influence this form of disease, and when treated by mercury or by sarsaparilla either separately or together, it often continues many months. The liquor hydrargyri oxymuriatis, applied as a lotion night and morning, produces a much more decided effect, and without affecting the general health of the patient.

The *lichen syphiliticus agrior*, or that form of lichen which has a tendency to ulcerate, is much more amenable to medicine, and readily yields to a course of blue pill, but is little influenced by the iodide of potassium.

The *prurigo syphilitica* is said by Rayer to require cinnabar fumigations; probably sarsaparilla is a more efficient remedy.

Of the squamous eruptions, *lepra syphilitica* is almost as intractable as the lepra vulgaris, and only occasionally yields to the internal uses of sarsaparilla or of mercury, or of both conjoined. The liquor hydrargyri oxymuriatis, used as a lotion, however, greatly facilitates the cure.

The forms of *psoriasis syphilitica* are efficiently treated by dressing the part with the unguent. hydrargyri nitrico-oxydi. If combined with diseased bones, the iodide of potassium must be exhibited also.

The treatment of the *exanthemata syphilitica* is extremely simple. The *roseola syphilitica febrilis* readily yields in about a week or ten days to saline medicines, attention to the bowels, and a milk diet.

The *roseola syphilitica annularis* usually rapidly declines when treated by the iodide of potassium; but if the disease be neglected, a copper colour for a long time marks the spots which have been the seat of the eruption.

The *purpura syphilitica* sometimes yields to mercury or to the iodide of potassium; occasionally, however, these cases are most rebellious to every remedy, antisyphilitic or otherwise. One case which had resisted mercury, the iodide of potassium, and sarsaparilla, at last gave way to a treatment of five grains of iodic acid three times a day.

Of the *pustular forms of the cutaneous diseases.*—Ecthyma syphilitica having the phlyzaceous pustule often yields to sarsaparilla, but appears aggravated by mercury. A case of this form of corona veneris was treated with remarkable success by the iodide of potassium grs. viij. ter die, the sore being dressed with the unguentum hydrargyri nitrico-oxydi.

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The only form of *vesicular* eruption in syphilis is *rupia*, a disease which requires much judgment in its treatment. The other cutaneous affections little impair the general health of the patient, but the tendency of this disease is so debilitating as rapidly to reduce the powers of the strongest man. Mercury in any form or quantity, exhibited internally or introduced by inunction, is highly dangerous and improper. Many cases treated even by small doses of mercury have terminated fatally, and large doses have been still more unsuccessful. There is one mode of treatment, however, which appears uniformly to succeed, or by dressing the sores with the unguentum hydrargyri nitrico-oxydi, and by supporting the patient either by sarsaparilla or the iodide of potassium, and the latter medicine is infinitely more beneficial than the former. But neither the sarsaparilla nor the iodide of potassium, although singularly successful in restoring the health of the patient, possess the property of healing the rupial sore. The practice, therefore, is first to remove the scab or crust by a poultice, and then to dress the sore with the unguentum hydrargyri nitrico-oxydi, and at the same to give the iodide of potash in eight-grain doses three times a day out of camphor mixture; and the combined effects of this treatment in curing this disease is quite remarkable. If sarsaparilla be prescribed, the patient must, in addition, be supported by wine or porter, or both.

The *Tubercular Syphilitic eruptions* readily yield to small doses of mercury, or to the iodide of potassium, but more certainly to the former. The broad tubercular eruption, or *tubercula syphilitica plana*, is often intractable, especially when it ulcerates. In these cases an ointment of the iodide of potassium, a drachm to the ounce, or the unguentum hydrargyri nitrico-oxydi, are useful applications; but under every mode of treatment the cure is long and protracted.

The *herpes preputialis* yields to any slight astringent lotion, as, a solution of half a grain of acetate of lead to an ounce of water, or to an application of zinc ointment.

For the cure of the cutaneous excrescences or growths, the remedies are almost as endless as the forms of disease. They may be removed by the knife, ligature, or by cauterization, or they may be destroyed by savin powder, by the liquor plumbi acetatis, by the tinct. ferri muriatis, the liquor hydrargyri oxymuriatis, or by acetic acid. The iodide of potassium and mercury, by inunction, have also been found useful in dispersing these adventitious growths. Ricord recommends sprinkling the parts with calomel, having first washed them with the chloruret of soda. Under every mode of treatment, however, these growths have a great tendency to return.

*Treatment of the Syphilitic affections of the bones.*—The treatment of the syphilitic affection of the bones and of the periosteum has hitherto been the "questio vexata" of syphilis. Some pathologists have contended that this class of disease will heal under a simple antiphlogistic treatment, but there is no sufficient evidence of this result, for long intervals have frequently elapsed, especially in seamen, from the first commencement of the affection before any medical treatment has been employed, yet without any mitigation or appearance of subsidence of the symptoms. The affections of the bones of the nose and of the palate are seldom painful, and the applications for advice in these cases are often long delayed. But the longer the delay the more aggravated and serious the disease, and the greater the chances of disfiguration and of exfoliation. It must be concluded, therefore, that without the aid of medicine the number of victims from this class of disease would be distressingly large, and their sufferings indescribably severe. Happily, however, we are provided with efficient remedies against these great evils in mercury, sarsaparilla, and more especially the iodide of potassium; and it will be seen that all these remedies are necessary in the cure of diseases of the bones.

In the cure of the hard periosteal node the properties of sarsaparilla are so doubtful that its exhibition in these cases is generally abandoned as inefficient or useless. It is admitted, however, that many cases of hard nodes will yield to mercury when given in such doses as to affect the system. Still there are many others in which this metal produces no such successful result, for although the patient is generally relieved as soon as ptyalism is established, yet the pathological state of the parts often remains unchanged; so that on the salivary discharge ceasing the pain returns, and the patient is doomed to many years' excessive suffering, or is only relieved during the time that he is under the fullest influence of mercury. It is painful even to reflect on the ceaseless agony under which these patients have often been seen to suffer. "Pain," says Mr. Carmichael, "is a mild term to express their tortures." It is impossible to determine with any accuracy the number of cases in which mercury is inefficient, but it must be large. Ricord states, "that mercury, only occasionally useful in the primary affection, is incontestably so in the secondary affections, as those of the skin, and again loses its curative properties in the tertiary accidents, or those of the bones." This, perhaps, is in excess, but there is no good writer on syphilis, from Ambroise Paré to Desruelles, who has not proposed cutting down on the intractable node, and destroying it either by actual cautery or by the hammer and chisel. A more efficient treatment of this affection was necessary, and the discovery of the virtues of the iodide of potassium as its surest antidote forms an epoch in the treatment of syphilis.

Indeed it appears to be clearly and irrefragably demonstrated that this salt is the great specific remedy in the cure of this form of secondary syphilis. Nor can the action of quina be considered more certain or more striking in the cure of ague than that of the iodide of potassium in the cure of the hard syphilitic node. Its effects in some hundreds of cases have been, with one exception, to remove the pain in a very few days; and, if the node be recent and the parts not extensively disorganized, to permanently cure the patient. It is only in the old chronic node, and when extensive morbid growths have formed, and such as we may now reasonably hope never to witness again, that the iodide of potassium has failed in effecting a permanent cure. In these cases of confirmed disease mercury is equally inefficient as a curative remedy, and never affords the relief that the patient in every instance receives from the iodide of potassium, and which generally lasts for a considerable time.

On comparing this new mode of treatment with that by mercury it has these advantages:—The relief from pain by mercury is seldom complete till the mouth is fully affected, while under the use of the iodide of potassium the patient is usually free from pain in three or four days, and almost constantly so within a week. Again, mercury often appears to aggravate the disease,



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and always impairs the constitution. On the contrary, the iodide of potassium has in all instances alleviated the disease, and the rapidity with which this class of patients increase in flesh and in strength is quite remarkable. The iodide of potassium also is useful in a much larger number of cases, and effects the cure without that train of disgusting circumstances which accompanies ptyalism, or that enlargement of the cervical glands, so common when mercury is used. The absorption also of the morbid growth is more certain, and the frequency of relapse diminished, while the cure is obtained in a much shorter time, and consequently at much less expense to the patient both of his constitution and of his purse. On all these grounds, therefore, the iodide of potassium must be considered as infinitely superior to mercury in the cure of this once formidable disease.

The iodide of potassium has been given in doses of 15, 20, and even 30 or more grains; but this is in excess, and generally produces headache, vomiting, and purging. Some constitutions, on the contrary, are offended even by one or two grains. The average dose, therefore, of the iodide of potassium has been found to be eight grains three times a day, and even this often causes three or four motions in the 24 hours. A smaller dose can hardly be recommended, for the patient's sufferings require immediate relief, and consequently we ought to begin with as large a dose as his stomach will probably bear. Eight grains, then, is the mean dose for an adult, and as it usually gives relief in three or four days it is plainly efficient. Some practitioners are in the habit of adding half a grain to a grain of pure iodine to the iodide of potassium; but supposing iodine to act in proportion to the quantity absorbed, and not by its mere acridity, this is a great medical error, for it disorders the stomach without in any sensible degree benefiting the complaint. It is determined, for example, that the iodide of potassium contains three-fourths of its weight of pure iodine; so that a patient taking 28 grains of the former in the course of 24 hours takes no less than 21 grains of the metal. The addition then of half a grain to a grain in the 24 hours of pure iodine is so trifling that it may be neglected; while its acridity is so great that Mr. Stone, of Christ's Hospital, formerly assistant apothecary at St. Thomas's Hospital, states, he used to be called to prescribe for 10 patients taking the compound of iodine and of the iodide of potassium for one that was taking the latter medicine only.

The modes of action of iodine cannot of course be ascertained; but it is absorbed, and perhaps has an affinity for the syphilitic poison, which it modifies, and deprives of a part of its power to inflict disease. Metallic iodine is supposed to be taken up by the absorbents, as hydriodic acid, the metal combining with the hydrogen of the fluids of the stomach. The iodide of potassium is probably absorbed in substance, and so rapidly, that iodine may be often detected in the urine within ten minutes after the patient has swallowed it. It is also found in the saliva, in the tears, in the milk, and probably in the other secretions of the body; but it has not been satisfactorily demonstrated in the blood, being either so rapidly removed as to exist only in quantities too minute for detection, or else resolved perhaps into its elements. The time that it may be detected in the urine, after it has ceased to be exhibited, is not yet determined; but in two cases no trace remained after forty-eight hours. It is remarkable that iodic acid, though a solid substance, is not detected in the urine, even after being exhibited in doses of six or eight grains, three times a day, for a considerable length of time, pointing either to a singular relative affinity of the lacteals for different medicinal substances, or supposing the substance to be absorbed, that it must be removed by some other organ or tissue than the kidneys. The iodic acid has likewise no similar property of curing the syphilitic node with the iodide of potassium. The best means of detecting the iodide of potassium in the urine, is first to add a solution of starch, and then a small quantity of a solution of chlorine. This latter agent immediately setting free the iodine, which combines with the starch, and produces the usual beautiful violet or indigo tint.

The quantity of iodide of potassium necessary for the cure of the hard node is probably in proportion to the pathological state of the part. Some patients, freed from their pains, ask to be dismissed at the end of a week, or before an ounce can have been taken. In general, perhaps, a month is about the average time of treatment, and the quantity used varies from four to six ounces; but when mercury has been previously and unsuccessfully employed, the quantity has sometimes exceeded a pound. It is singular that the hard node, although it is often permanent on the lower extremities, is almost always absorbed when seated on the upper extremity.

The hard node sometimes suppurates, and this form of periostitis was formerly frequent. This change in the pathological state of the parts requires a different treatment, and demonstrates the truth of the remarkable law, that when inflammation terminates in abscess, the remedy which, timely administered, would have prevented so untoward an event, now loses all its power over the disease, and even aggravates the symptoms. As soon, therefore, as the node runs into suppuration, mercury ceases to be in any degree beneficial, while sarsaparilla seems to be the specific remedy. It is probable, however, that the iodide of potassium also will heal, or beneficially influence, this state of the node; at least the iodide of potassium greatly relieves the pain, and apparently accelerates the healing of the part.

The *hard cranial node*, although having the same external characters as the hard node on the long bones, it has been shown, has an entirely different structure, and consequently some doubt might be entertained whether the same medicinal agents would be found equally beneficial in this class of cases. Experience, however, has shown that they have exactly the same powers. Mercury often removes them, but they often suppurate, and have a great tendency to relapse under that treatment. The iodide of potassium, however, gives more certain and quick relief, more readily occasions absorption, prevents ulceration, and in fact cures the disease. When the node has suppurated, either sarsaparilla or the iodide of potash will heal it; but the two remedies combined are perhaps the most efficacious. Again, should the node have ulcerated, the iodide of potash, either *per se* or aided by the ung. hydr. nitr. oxydi, effects, even in this state, the cure.

Syphilitic inflammation of the *substance* of the long bones may exist *per se*, or may co-exist with the hard periosteal node. It has no diagnostic symptoms by which it can be distinguished from the hard node, except perhaps that the bone is more generally enlarged, the pain greater, and the disease more intractable. As

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long as the inflammation is limited to the superficies of the bone, or to some portion of the cancellous structure, or merely causes some modification of the medullary matter, it probably yields either to mercury or to the iodide of potassium. When, however, an abscess forms in its substance, exfoliation must of necessity take place; all specific remedies lose their power, and opium is the only mode of procuring relief. As soon, however, as the diseased portion of the bone is detached, sarsaparilla appears to facilitate the formation of granulations, and under its use the part heals.

The *soft gelatiniform* or *gummy* node is a disease of much less frequent occurrence than the hard, or even the suppurating node, and is indeed but rarely seen. These nodes are rarely cured by general treatment, or by mercury, or by sarsaparilla. Neither does the iodide of potassium satisfactorily influence them. Cullerier has proposed, while they are yet incipient, to attack them by blisters or a caustic solution, and states he has often succeeded. Ricord also praises this mode of treatment. One patient who had lost the use of his right arm from pressure on the nerve by one of these tumors, whom every treatment was unsuccessful, mentioned that his sister had been operated on for a node similarly situated, and that she had died.

When the syphilitic poison has fallen on the bones of the nose, palate, or face, neither mercury nor sarsaparilla, though continued for many weeks, have appeared to interrupt the course of the disease, or to prevent exfoliation. Still, in quite the incipient stage, the iodide of potassium has often fixed the loosened bones and cured the patient. As a general rule, however, in the advanced stages, this medicine, although it improves the general health, has no power over the affected part, and it is necessary to combine with it a local treatment. When the bones of the nose, therefore, are affected, the iodide of potassium should be exhibited in the usual manner; but at the same time the black wash should be injected twice or thrice a day up the nostrils; or, what is better, the interior of the nose should be anointed with the unguentum hydrargyri nitrico-oxydi, as far as the probe can reach. This latter mode of treatment is uniformly successful, and always saves the nose, and consequently the patient from being disfigured. When the bones of the palate are affected the general and local treatment are the same, but the unguentum hydrargyri nitrico-oxydi should be applied more cautiously to the ulcerated part, on account of its being readily removable by the tongue.

*Treatment of Syphilitic Angina.*—The treatment of mild cases of syphilitic angina, whether the tonsils be or be not swollen, is by moderate doses of mercury, as of the pilulæ hydrargyri gr. v. bis vel ter die, or even by sarsaparilla. But in severe cases these remedies, however judiciously administered, will not cure the disease, but, on the contrary, often aggravate it; and it is essential that the attention of the student should be drawn to the value of local remedies in this affection. The treatment of these severe cases is to prescribe eight grains of the iodide of potassium ter die, which, without having any power to heal the throat, will greatly support the strength and improve the health of the patient, and in addition to this the ulcerated portions, as far as they can be reached, should be touched night and morning with the unguentum hydrargyri nitrico-oxydi, and under this treatment the ulcers readily granulate, and the throat rapidly heals.

Not only will the deep-eating ulcer heal under this local treatment, but also the superficial and intractable serpiginous ulcer, and the number of cases successfully treated in this manner is now very large, and quite sufficient to establish the great value of this practice. The best mode of applying the ointment is by a piece of lint, attached to the end of a pencil. As a general principle it is seldom that mercury, applied in this manner, affects the mouth; but in two or three instances it has had that effect, and in each instance there was an immediate extension of the pharyngeal ulceration, showing that the amelioration is occasioned by the local stimulus, and not from any constitutional affection of the system.

*Treatment of Syphilitic Ophthalmia.*—The cure of syphilitic ophthalmia, whether the inflammation affects the conjunctiva, the iris, the cornea, or all of these parts, is by mercury, which is the great specific and only remedy in these cases, for neither sarsaparilla nor the iodide of potassium appear to have the slightest influence in controlling the disease. In every case therefore of *acute* syphilitic ophthalmia mercury should be given in such quantity as to ensure the patient's mouth being affected in a few days. For this purpose, two grains of calomel twice or thrice a day, or five grains of calomel every night, are in general sufficient. Some authorities prefer the proto-ioduret of mercury to calomel, yet it seems unimportant by what means salivation is produced. When the mouth is affected the pains and inflammation in general subside. In a few cases, however, a considerable chronic conjunctivitis remains, which is best treated by the unguentum hydrargyri nitrico-oxydi, applied locally to the eye.

Many writers recommend, in addition to mercury, that blood-letting, both locally and generally, should be had recourse to, and that to a large amount. But this practice appears altogether unnecessary, and must in many cases be highly injurious by favouring the action of the poison on a debilitated system. Blisters have also been recommended, and are occasionally of service, but are seldom essentially necessary. The circumference of the orbit, and also the mucous membrane of the nose, is, by many practitioners, smeared with belladonna ointment; but there is seldom any necessity even for this application.

When the syphilitic ophthalmia is *chronic*, an alterative mode of treatment is often sufficient. A gentleman whose sight was considerably impaired by the deposition of a considerable quantity of lymph on the cornea, was directed to take five grains of the pilulæ hydrargyri every night; and under this treatment the nebulæ in a few days disappeared, although the constitution was not in the slightest degree affected.

*Treatment of syphilitic affections of the joints.*—When the poison falls on the ligaments and synovial membranes, these diseases are in most cases obstinate of cure; but, as a general principle, the affections of the elbow-joints readily yield to the iodide of potassium. Of the other joints it is difficult to determine whether they yield more readily to small doses of mercury, or to the iodide of potassium. The latter, however, should first be tried. One gentleman who has paid much attention to the effects of the iodide of potassium in these cases, says, "Respecting the treatment of the affections of the ligaments, with considerable swelling of the joints, very much resembling rheumatism, the iodide of potassium is an invaluable remedy. It produces good nights, reduces the swelling, and promotes the general health."

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In the foul wards the patient often asks for it, and it is frequently successful.

*Dietetic Treatment.*—Mr. Hunter taught, that "the manner of living under a mercurial course need not be altered from the common;" but it has been found that a dietetic treatment so much overlooked by Mr. Hunter greatly influences the cure, and that the healing of the primary sore by the unaided efforts of nature is hardly to be obtained except by adopting an exceedingly severe regimen, or the "cura famis." The influence of a dietetic treatment is, therefore, strongly marked in the case of syphilis.

The "cura famis," as the term implies, consists in limiting the patient to an extremely low diet, to confining him to the house, and also to using some trifling local application. Desruelles says he found that the mean duration of a number of cases of primary sore, treated by the "cura famis," limited to a vegetable diet, was thirty days; while a similar number of cases, treated on the same plan, but allowed animal food, was fifty days. He found also a similar difference when mercury was used; for the mean duration of a limited number of cases treated by mercury, and limited to a vegetable diet, was forty-four days, while when animal food was allowed it was fifty-six days. Ricord agrees with Desruelles, that, as a general principle, animal food ought to be avoided in the cure of primary syphilis; but adds, that in feeble constitutions he has often seen the worst consequences from its adoption, and that it is, consequently, often necessary to give the patient the support of an abundant and liberal diet.

In the cure of the secondary symptoms, the patients are generally impatient when limited to a milk or vegetable diet, and perhaps iritis is the only disease in which a forbearance from animal food is absolutely necessary. In rupia, in sloughing sore throat, and when the patient is broken down by severe affections of the bones, a full diet of animal food, with a liberal allowance of wine and porter, appear greatly to facilitate the patient's recovery. In very severe cases, it should be added, there is no greater restorative than change of air.

*Preventative Treatment.*—When a party has been exposed to infection, there is no other preventative remedy than extreme cleanliness. The chlorides have been recommended, but they probably have no power to neutralize the poison. Still, supposing them to possess such a property, yet the application of these, or of the bichloride of mercury, or of any other substance, must, under any circumstances, be too late to prevent the absorption of the poison, and, consequently, the contamination of the system.

### Of the Poison of Gonorrhœa.

Gonorrhœa is a contagious disease, producing a specific suppurative inflammation of the mucous membrane of the urethra and glans in the male, and of the mucous membrane of the genital organs in the female. It occasionally also affects the mucous membranes of the eye, and of the rectum.

The history of the first appearance of gonorrhœa is extremely obscure, and in the absence of all evidence connecting this disease with the remoter periods of medicine, two hypotheses have been entertained—first, that it prevailed prior to the introduction of syphilis; and again, that it was first observed about half a century after the breaking out of that disease. The strongest and most conclusive arguments are supposed, however, to favour the first hypothesis.

*Remote Cause.*—The combination of causes which produced this poison in the human subject are entirely unknown. Many physicians have thought, with Ricord, that any acrid or irritating discharge in the female would cause this disease. "But how many men," says Beaumés, "know their wives, or other women, when affected with leucorrhœa so acrid as to excoriate the thighs of the parties, or even when labouring under the discharge of incipient cancer, without ever contracting gonorrhœa; yet if these same women become faithless, their husbands are immediately infected."

Whatever may be the source of this poison in its habits, it seems peculiar to man; for Mr. Hunter says, "I have repeatedly soaked lint in matter of gonorrhœa, and introduced it into the vagina of bitches, into the vagina of asses, and under the prepuce of dogs, without any effect. I have also made incisions under the skin, and it has only produced a common sore."

*Predisposing Causes.*—In general the more feeble the health of the party, the greater the susceptibility, and the longer the duration, of the disease.

It appears *climate* has an influence in the occurrence of gonorrhœa; for, by the returns of the British army, that disease is much more frequent among the troops stationed in this country than in the Mediterranean and the West Indies. The infrequency of gonorrhœa among the inhabitants of warmer climates is owing, perhaps, to the practice of more frequent ablution, and, consequently, to greater cleanliness. According to the records of the Hôpital de Vénériens, at Paris, this disease is greatly more frequent in spring and autumn than at any other seasons of the year, perhaps owing to the holding of a greater number of fairs and festivals at those periods.

*Contagious.*—The evidence of the contagious nature of this disease is of the strongest description—namely, the constant contamination of a healthy person having intercourse with a diseased one. In a very few instances, the contagious nature of this disease has been proved by a voluntary application of the poison to the urethra in the male, for the purpose of settling this disputed question.

*Fomites.*—The possibility of this disease being communicated by inoculation is a sufficient proof of this fact; but the transmission by fomites is extremely rare.

*Susceptibility not exhausted.*—It is probable that the susceptibility to the poison of gonorrhœa is never entirely exhausted, although it has many degrees. The most general maxim is, that the first gonorrhœa is the most severe, and the succeeding ones become milder and milder, till in some cases the danger of infection almost vanishes.

*Co-exists.*—The poison of gonorrhœa is capable of co-existing with many other poisons. It occasionally happens that the discharge becomes most profuse in the latter stages of typhus fever, while in the earlier ones it may stop altogether. It frequently also co-exists with erysipelas, and probably with every other disease known to depend on a morbid poison.

*Modes of Absorption.*—This poison is absorbed by all the mucous membranes it is usually brought in contact with; and, reasoning from all analogy, must infect the blood before it produces its specific action; and if we admit orchitis, and some cutaneous eruptions, to be

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secondary actions of the poison, and not the mere effect of sympathy, this law appears satisfactorily proved.

*Period of Latency*.—The time which elapses after contamination before the discharge is established, varies considerably in different persons; but every period between six hours and six weeks has been mentioned as the period of latency. In general, however, it is from three to twelve days.

*Pathology*.—The theory of this disease, as deduced from analogy, is that the poison of gonorrhœa is absorbed by the mucous membranes, and infects the blood; and after a given period of latency, produces suppurative inflammation of the mucous membrane, to which it has been distinctly applied, whether of the urethra and glans in the male, the genital organs of the female, or of the rectum, nose, lip, or eye of either sex. It is probable that this poison has only one secondary action, or on the testicle, when it produces in a given number of cases orchitis. Many authors, however, have attributed a slight inflammation of the fauces, and also certain slight cutaneous eruptions, to this poison; but the proofs are at present insufficient to establish this doctrine. Bubo is probably the result of sympathy, and stricture of local inflammation.

The following are the parts in the male and in the female which it more commonly affects:—

*Parts primarily affected in the Male.*

| | | |
|---|---|---|
| Urethra | producing | Gonorrhœa. |
| Glans, Prepuce | ,, | Gonorrhœa spuria. |

*Parts secondarily and accidentally affected in the male.*

| | | |
|---|---|---|
| Testicle | producing | Orchitis. |
| Inguinal glands | ,, | Bubo. |
| Tissues of the urethra | ,, | Stricture. |

*Parts primarily affected in the female.*

| | | |
|---|---|---|
| Vulva, Vagina, Urethra | separate or combined | producing Gonorrhœa. |

*Parts secondarily and accidentally affected in the female.*

| | | |
|---|---|---|
| Inguinal glands | producing | Bubo. |
| Uterus | ,, | Uteritis. |

The discharge resulting from the inflammation is in either sex a white, yellowish, or greenish pus, according to the state of health of the patient and the duration of the disease, and is sometimes mixed with blood. It is likewise alkaline, and possesses the other usual chemical properties of ordinary pus. It was formerly supposed to proceed in the male, from ulceration of the urethral membrane, but subsequent observation has shown as a general law, that gonorrhœa arises from a suppurative inflammation of the mucous membrane of the urethra, without breach of surface, and that ulceration occurs only in a few rare cases.

It is generally supposed that in gonorrhœa the inflammation of the mucous membrane of the urethra is partial, and Haller, Mr. Hunter, and others have limited its extent to the fossa navicularis, or the portions immediately under the glans. But Boyer and Cullerier consider that the redness found in the anterior portion of the urethra after death is caused solely by the part being pendent. The fact also that extensive suppurative inflammation often exists in mucous membranes, without any redness being discoverable after death, renders Mr. Hunter's opinion rather questionable, especially as the pain in the perinæum, and the formation of stricture commonly in the bulbous part, show that the remoter parts are oftener inflamed.

The inflammation of the mucous membrane of the urethra frequently extends to the surrounding tissues, or to the cells of the corpus spongiosum, so that they often become bound down by adhesive inflammation, and the phenomena of chordee are the consequence; small tumors also sometimes form in the course of the urethra, and which may suppurate and burst, either into the cavity of the urethra, or externally; and sometimes in both directions, so that a false passage is the consequence, and hence fistula in perinæo.

When gonorrhœa is chronic, the urethra is not unfrequently the seat of *stricture*. The formation of stricture is as follows. When the canals of the body, as the intestines or œsophagus, are inflamed, the affected part contracts, and while thus contracted they often become bound down, and thus their diameter is greatly diminished. According to Mr. Hunter, stricture of the urethra is seldom of greater breadth than if the part had been surrounded with a piece of pack-thread; but, occasionally, the urethra has been found contracted for more than an inch. A stricture may form in any part of the urethra, but the most common seat is about four and a half inches from the origin of the glans, and again at between six and seven inches, or just behind the bulb. They are usually slow in forming, and sometimes thirty to forty years have elapsed from the time of the patient suffering from gonorrhœa to the formation of a stricture.

The mucous membrane covering the strictured portion is sometimes natural in its appearance; at others a little thickened, and occasionally the surface is abraded and ulcerated. The two last effects are generally produced by attempts to pass an instrument, which sometimes causes false passages.

When the gonorrhœal inflammation is violent and long-continued, the prostate has become acutely inflamed, and has even suppurated.

A swelling of the testicle or orchitis is a frequent occurrence in gonorrhœa, but so few persons die of this affection, that its pathology is little known. The epididymis, the cord, and the vas deferens, however, are the parts first attacked, while the body of the testicle subsequently enlarges, and sometimes acquires a very considerable magnitude. If the disease continues, lymph or serum is thrown out, and from the latter cause hydrocele often occurs. The left testicle is more frequently affected than the right, and it is only occasionally and rarely that both are affected.

Another occasional effect of gonorrhœa is bubo, or inflammation of the inguinal glands, and which may terminate in induration with enlargement, or else in suppuration.

In the *female* the vagina is usually the principal seat of gonorrhœal inflammation, and some authors contend that it is confined to this part, but there are cases in which pressure on the meatus urinarius produces a flow of pus, the vagina being in no degree affected. These parts, therefore, may be either separately or conjointly affected. When the vagina and urethra are alone diseased, nothing is to be seen externally; but on separating the labia, we observe some inflamed points, which are the orifices of enlarged mucous glands. In severe cases, the parts both external and internal are

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more or less swollen, and also the membrane enveloping the clitoris; and this inflammation sometimes extends to the neck of the uterus, causing exquisite pain. When the irritation is great, one or more small abscesses form occasionally in the cellular tissue of the labia.

In chronic gonorrhœa the appearance of the parts is often natural. Mr. Hunter states he had frequently examined patients who complained of the usual symptoms, as increased discharge, pain in making water, and soreness, and yet could perceive no difference between these parts and such as were quite healthy.

In the female, stricture of the urethra is extremely rare, but it is not uncommon to find caruncula or polypus in the interior, or at the orifice of the urethra, causing great pain, and often keeping up the discharge till their removal, either by excision or by cauterization.

According to Ricord, gonorrhœal ophthalmia always proceeds from the direct application of the matter of gonorrhœa to the eye, producing ophthalmia in the highest degree. As early as the first or second day, the conjunctiva, as well as the internal surface of the eyelids, as also the globe of the eye, is gorged and swollen, so as to form a considerable prominence, and give an appearance of the cornea being depressed; and this salient state of the conjunctiva is considered by Lagneau as almost peculiar to this form of ophthalmia, and its diagnostic symptom. From the first moment of attack light is painful, and the secretions of the eye resemble in every respect the yellow-greenish discharge of urethral gonorrhœa, and so acrid that it inflames those parts of the cheek and nose over which it flows. The eyelid now becomes swollen, and the tumefaction of the conjunctiva excessive. In bad cases, the cornea also becomes nebulous, or ulcerates, and procident staphyloma follows, so that the humours of the eye escape, and blindness is the inevitable consequence; a result which may take place in four or five days, and has been known to occur in twenty-four hours. In the majority of cases, however, the ophthalmia is chronic, and the patient recovers without any disorganization of the eye.

*Symptoms.*—Gonorrhœa may be acute or chronic; and in the male there are two varieties of this disease, or gonorrhœa and gonorrhœa spuria.

Acute gonorrhœa in the male is the discharge of a purulent matter from the urethra. Its first symptom is generally an itching about the orifice of the urethra, which some authors have described as not disagreeable; and this usually comes on about forty-eight hours after contamination. At the end of three or four days it becomes distressing, the lips of the urethra become red and swollen, and pain is now felt on passing the urine, which increases till it becomes so intense as to be termed scalding; the patient finds walking and riding difficult and painful. This inflammation extends also to the glans, which is swollen, tense, and according to Mr. Hunter resembles "a ripe cherry." The parts are now often sore, greatly distended, and at night often intolerably so; and frequently attended with *chordee*. Occasionally the inflammation extends to the prepuce, and causes phymosis or paraphymosis.

The discharge usually begins a few hours after the titillation or itching. It is first a semi-transparent fluid which glues up the orifice of the urethra, and then, about the sixth or eighth day, and often sooner, a puriform matter flows in considerable abundance from the urethra, and which may be white, yellow, green, or any other variation of colour or of consistency common to pus.

The inflammatory symptoms are usually at their height about the fourteenth day, and continue so till the twenty-fifth or thirtieth, when the pain diminishes; the parts become less irritated, and the discharge becoming less and less abundant at length disappears. Such is the usual course of gonorrhœa; it may, however, be much milder or much more severe. In general, gonorrhœa does not terminate till the thirtieth or fortieth day; but in a few instances it ceases in a few hours; while in others it is prolonged for many months. In the latter case it is termed a *gleet*. The matter of gleet is supposed to be non-contagious; but this doctrine is dangerous, and is probably the cause of frequent infection immediately after marriage.

When the disease is complicated with *bubo*, the inguinal glands are swollen, sore to the touch, and sometimes acutely painful, although they do not usually suppurate.

A swelling of the *testicle*, or *orchitis*, is frequent in gonorrhœa, and is calculated to occur in one of every three cases. This affection may take place at any stage of the disease, but is most common towards its decline, and usually coincides with a diminution or entire suppression of the gonorrhœal discharge. When the testicle inflames the patient suffers excessive pain in the part extending to the back, loins, and pelvis. The stomach and bowels also generally sympathize, and nausea and even vomiting are common symptoms. After being inflamed it is generally a long while before the swelling of the testicle entirely subsides, but by degrees it diminishes, and from being much harder becomes even softer than natural; and many years may elapse before the epididymis regains its natural texture.

The disease termed *gonorrhœa superficialis vel spuria* consists of an inflammation of the membrane covering the glans penis and inner surface of the prepuce, followed by a purulent discharge similar to that from the urethra. The glans and prepuce are commonly greatly swollen, red, and painful, and their surfaces are sometimes superficially ulcerated. In this latter case, the extensibility of the glans being much greater than that of the prepuce, phymosis or paraphymosis may take place, and, in some instances, the constriction has been so considerable as to produce gangrene and sloughing of the entire penis. When sloughing attacks the glans, it usually begins in the fossa or root of that part, or at the insertion of the prepuce.

When the *female* is affected with gonorrhœa the vagina is often alone attacked, and this part not being endowed with much sensibility, the pain is trifling. When, however, the disease extends to parts more painful than the vagina, as the inner surface of the labia, the nymphæ, clitoris, caruncula myrtiformis, and meatus urinarius, the parts are so sore and painful as not to bear to be touched; the patient can hardly walk, and great pain is experienced when the urine comes in contact with the inflamed surfaces. The parts affected are also often greatly swollen, so that we can hardly introduce the finger into the vagina; and the discharge is so acrid that it excoriates the parts over which it flows. In some cases the bladder sympathizes, and produces, as in men, the same irresistible desire to void urine, the same micturation, and sometimes the same retention. The inflammation also sometimes affects the mucous glands, producing hard swellings of the inner surface of

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Elementary Principles of Medicine.

the labia, which occasionally suppurate and produce small abscesses in the vagina.

Women also very often labour under chronic gonorrhœa without any suffering, and consequently often communicate this disease without knowing that they are themselves diseased, and no more difficult question exists in medicine than to determine whether they are or are not affected. "The kind of matter," says Mr. Hunter, "gives no assistance in distinguishing gonorrhœa, for it often happens the discharge in fluor albus puts on all the appearances of the venereal matter, and an increase in the discharge is no better mark by which we can distinguish the one from the other. The appearance of the parts also gives us but little information; for I have frequently examined those who confessed all the symptoms, as an increase of discharge, pain in making water, soreness in walking, or when the parts were touched, yet I could see no difference between them and sound parts. I know," he adds, "of no other way of judging in these cases where there are no symptoms sensible to the person herself, but from the circumstances preceding the discharge, and the connexions she may be supposed to have had with other diseased persons."

Gonorrhœal ophthalmia is very marked in its symptoms, and is always accompanied with great pain and intolerance of light.

*Treatment.*—The treatment of gonorrhœa in the male is either by medicines which are supposed to have a specific action on the parts, or else by general treatment. In the former, the object is to cure the disease in a few hours: in the latter, the disease is allowed to run its course, which is commonly from five to six weeks, the practitioner only interfering to obviate symptoms.

Among the specific remedies is the balsam of copaiba. This medicine is considered to be a species of turpentine from which may be distilled a volatile oil, leaving a pure resin as a residue. The balsam, however, is supposed to be more efficacious, and to sit more easily on the stomach than either of its component parts. The dose, in the last pharmacopœia, is described as being from a scruple to a drachm; but the medicine has been employed in much larger doses both in this country and on the continent. Monteggin and Fuller have given from two to three drachms for a dose, while Ribes found, in consequence of a mistake made by a patient, that it might be given to the amount of one or two ounces; and he has prescribed it in this dose in every stage of gonorrhœa, and even when accompanied with swelled testicle, bubo, and gonorrhœal ophthalmia; and he gives many instances of swelled testicle cured by these large doses. Rossignol also states that he cured upwards of 300 cases in less than a week by one to two drachms a-day. These practitioners gave the balsam pure, or mixed with syrup, or mucilage, or yolk of eggs, or with powdered sugar, or else directed it to be taken swimming on the top of a glass of wine or of lemonada, or taken out of an effervescing draught.

This medicine, however, thus exhibited, often makes a most disagreeable impression on the stomach, so that, by many patients, it is constantly rejected. MM. Velpeau, Brettoneau, and Labat have, consequently, given it as an enema dissolved either in mucilage or yolk of egg in doses varying from ʒ j. to ℥ j. a day, and added to it laudanum to cause it to be retained. Velpeau found this method produce its best effects between the fourth and seventh day, and that, after the eighth or tenth day, it either entirely succeeded or entirely failed.

It has been proposed to render copaiba more palatable by solidifying it by gradually mixing with it $\frac{1}{16}$th of its weight of calcined magnesia; by which process, at the end of a fortnight, it acquires the consistency and transparency of gum, so that it can be made into pills; whereby much that is disagreeable both in its taste and odour is avoided. Copaiba, however, is so much the more efficacious as it is exhibited in a liquid state, that unless the vomiting or purging which it sometimes induces requires an adjuvant, it should be administered without combination; and, with this view, it has lately been enveloped in capsules, which have rendered it less distasteful, but perhaps not so entirely as has been generally imagined. When copaiba is given by the mouth, it should not be taken till three or four hours after eating, else it produces great disturbance of the digestive organs; and many patients therefore generally prefer taking this medicine night and morning. It is singular that persons who take copaiba for the first time, especially out of spirits, often find it pleasant to the taste. The first eructation, however, destroys the illusion, and gives an entire disgust to what they had found so pleasant.

Copaiba has been known as a remedy for gonorrhœa since the year 1702, and that it will cure many patients must be admitted. Still it often fails: sometimes makes everything worse, and no one can tell the cases in which it will or will not succeed. Mr. Hunter thought so little of this remedy, that he affirms "there is no specific antidote for gonorrhœa;" "that treatment is seldom of any kind of use, perhaps not once in ten cases;" and, upon the conviction that every gonorrhœa cures itself, he adds, "I gave certain patients pills of bread, and the patients always got well, but some of them, I believe, not so soon as they would have done had the artificial methods of cure been employed." Ricord says that it seldom stops the discharge on the instant "*d'emblée*;" or, should the discharge rapidly cease under its use, it often re-appears on discontinuing the medicine, and again disappears on resuming it,—so that to obtain a durable effect, the patient must continue its use for eight or ten days after the cessation of all discharge. Ricord conceives the best chances of success are, to exhibit it during the first four days from the first appearance of the disease, or else after the acute stage is passed. This eminent surgeon, however, is so little satisfied of its specific properties, that he recommends our applying twenty, thirty, or forty leeches to the perinæum in every case where pain is present, before we exhibit the copaiba. Another of his methods also is to introduce an armed bougee to superficially cauterize the urethra, or else a graduated injection, beginning with a quarter of a grain of nitrate of silver to an ounce of water, and gradually increasing it till some effect is produced.

Another substance has been for some years used for the specific or abortive treatment of gonorrhœa, or cubebs. This medicine is admitted to offer much fewer chances of success than copaiba; indeed it seldom stops the discharge at once. It is singular that a substance so powerfully pungent should be taken in many cases throughout the whole disease without apparently influencing its course. These are the means we possess for attempting the cure of gonorrhœa by a specific or abortive treatment.



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Daily experience, however, shows that gonorrhœa often terminates spontaneously, and without the aid of medicine; and its usual course, when the patient is continent and abstains in a great measure from animal food, from wine, and from strong exercise, is to attain its height in about a week; to continue in this state about a fortnight, and then gradually to decline, so that at the end of five or six weeks the disease terminates. In ordinary cases, therefore, it will be plain that, although much prudence is necessary, still that much medicine is not essential. A general treatment is consequently often substituted for the specific, and the usual method is some gentle purgative to slightly act on the bowels, as the sulphate of magnesia or the iodide of potassium. Mr. Carmichael recommends an addition of the solution of tartarized antimony to the former salt; that medicine, preventing "the patient from indulging a good appetite, lessens inflammation, and is the best preservative against painful erections or chordee." In the second stage if it should be thought necessary, he directs, and it is the practice of the profession generally, the use of copaiba in as large doses as the stomach will bear, or else of cubebs; but the latter medicine, he states, has in the majority of cases disappointed his expectations.

There are many persons, however, who prefer an entirely local treatment, or are induced to conjoin some local measures with the general treatment. The simplest practice is, as soon as the discharge appears to direct the patient to steep the penis in moderately hot water for a few minutes, or till a degree of faintness is produced, and to repeat this fomentation two or three times in the twenty-four hours. This mode of applying heat is exceedingly exhausting, and if the disease be indolent often removes it in a few hours.

A treatment by injections, however, is more practised; and the forms of injection are without number, every practitioner thinking, or wishing to make the world think, his own the best. Some venture to throw up one so powerful as to be composed of ten grains of nitrate of silver to an ounce of distilled water. Ricord recommends a graduated injection, beginning with a quarter of a grain of nitrate of silver, and gradually increasing the quantity till some decided effect is produced. He also recommends the acetate of lead, or the tinct. opii. Mr. Carmichael recommends half a grain to a grain of the oxymuriate of mercury in six or eight ounces of lime-water, or from two to four grains of the sulphate of zinc or of the sulphate of copper in the same quantity of rose or other distilled water. But formulæ for injections are without number.

Mr. Hunter's direction for using injections ought never to be forgotten. "I think," he says, "irritating injections should never be used when there is much inflammation, especially in constitutions that will not bear a great deal of irritation. Nor should they be used when the specific irritation has spread beyond the specific distance; nor when the testicles are tender, nor when the discharge ceasing quickly they have become sore; nor when the perinæum is very susceptible of inflammation, especially if it has formerly suppurated; nor when there is a tendency in the bladder to irritation, which is known by the patient having had for some time a frequency in making water. In such cases I have not succeeded with them; they not only do no good, but frequently do harm, for I have seen them make the inflammation spread further in the urethra, and I think I have had reason to suspect that they have been the cause of abscess in perinæo. But in cases that are mild, and in constitutions that are not irritable, injections often succeed, and remove the disease almost immediately. The practice, however, ought to be attempted with caution, and not perhaps till milder methods have failed. Emollient injections are the most proper applications; and where the inflammation is very great indeed, we often find that a solution of gum-arabic, milk and water, or sweet oil will lessen the pain and other symptoms when the more active injections have done nothing, or seemed to do harm."

When injections are had recourse to they should be used cold, and thrown up three or four times a-day with a moderate force. The patient should seat himself on a chair, introduce the pipe, and then pressing the lips of the urethra gently, allow the injection to run down the canal. As soon as the discharge is stopped the injection should be left off.

In spite of the above local and general treatment the discharge may continue, and the disease, after a few weeks' duration, is now termed a gleet. The cause of the continuance of the discharge is supposed to depend on some irritation of a limited portion of the urethra. This point is sometimes situated towards the meatus urinarius; at others towards the bulb; and, according to Beaumés, in eight out of ten cases towards the prostatic portions of the canal. In this state of parts this gentleman recommends a catheter to be passed, in order to determine the exact distance of the prostatic portion by ascertaining the point at which the urine does not flow. He then withdraws it, and, introducing an armed catheter, cauterizes the affected part. Ricord carries this practice still further, and cauterizes the whole urethra. When the diseased portion is in perinæo, much advantage has been derived from a few leeches, or from a blister.

When the *testicle* becomes inflamed and enlarged in this disease, quiet and a horizontal position are essentially necessary. The patient should also be placed on a low or milk diet. The medical treatment consists of the application of fifteen, twenty, or more leeches, according to the severity of the attack, to the scrotum, and, on their falling off, fomentations or a linseed poultice should be applied, to encourage the bleeding and to assuage the pain, and when the pain is excessive forty to sixty drops of tinct. opii may be sprinkled over the surface of the cataplasm. This treatment often gives relief in a few hours; but should the pain recur the leeches should be repeated, and in all cases the patient should either foment night and morning, or repeatedly change the poultice. Besides the local treatment, internal medicines are of essential benefit, and of these the iodide of potassium is perhaps the best, and eight or ten grains given three times a day often greatly accelerates the cure. When mercury is given it should be in alterative doses, and with or without the sulphate of magnesia, according to the state of the patient's bowels. Under this treatment the disease is speedily mitigated, and generally subsides in ten days or a fortnight. In some cases, however, from improper treatment, or from other cause, the testicle remains much enlarged and greatly indurated. In this state an ointment, composed of a drachm of the iodide of potassium to an ounce, should be gently rubbed over the affected testicle night and morning. The iodide of potassium also taken internally, in the usual dose, still continues

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to be the most valuable remedy under these circumstances.

Should *chordee* exist in any severe degree, it is important to assuage the sufferings produced by this state of parts, and, besides cold to the part, the most powerful remedy is ten grains of camphor combined with one grain of opium, in pills or as an enema. Ricord states that this treatment is asked for every day in the wards of the hospital by those patients who have already made trial of it.

In the treatment of gonorrhœa in the *female* it is generally admitted that the specific treatment by copaiba or by cubebs is entirely inert, or only useful when perhaps the urethra is affected. In general, then, the treatment of gonorrhœa in females is extremely simple, or by rest, low diet, and diluents, and especially by a weak solution of the nitrate of potash and frequent warm ablutions, or emollient injections, or, should the bladder be affected, a large cataplasm may be applied over the abdomen. In addition to these means, the bowels should be kept freely open, and, if the symptoms be extremely severe, some blood may be taken from the arm, or locally by leeches, as may be thought best.

When the acute stage is passed, astringent injections may be had recourse to, and Ricord recommends the acetate of lead or alum, in the proportions of an ounce to an ounce of distilled water, and, by the aid of injections and of pledgets steeped in these solutions, he estimates that sixty women out of a hundred are cured in the space of twenty days to two months. In still more chronic cases the injection often requires to be varied, and those of the sulphate of zinc, of oak-bark, or of hydrargyri oxymuriatis are among those most commonly substituted. In cases where granulations have formed, or a slight ulceration exists at the orifice of the urethra, the diseased portion should be cauterized with the nitrate of silver or other escharotic.

Emollient fomentations and injections should be used warm, but astringent injections should be used cold. They should be thrown up by means of a syringe with a bent pipe, terminated by a bulb pierced with holes, and the pipe should be of that length that it may be introduced into the vagina without hurting the neck of the uterus. The position of the patient is not indifferent, and she should be recommended to inject in bed with the pelvis raised.

In the treatment of *gonorrhœal ophthalmia* in either sex the means must be active, and any hesitation in their employment, says Ricord, "frequently occasions loss of sight." If the patient be strong, blood should be taken from the arm, and twenty, thirty, or forty leeches should be applied on a level with the alæ of the nose and in the course of the jugular vein, but carefully avoiding the eyelids. Many practitioners now content themselves with applying emollient poultices, but Ricord recommends that the eyelids be inverted and the palpebral, as well as ocular, conjunctiva be cauterized with argentum nitratum until the surface is whitened; and this being done, cold water should be injected, so as to wash the nitrate of silver off the conjunctiva and cornea. As soon as this slight operation is finished, the eye is to be covered with compresses steeped in a cold decoction of poppy-heads, and this cauterization may be repeated every day or every second day. Should ecchymosis exist, he recommends the affected part to be removed by means of hooked tenacula and the curved scissors.

The treatment of stricture, and of diseases of the prostate resulting from gonorrhœa, is so completely within the province of surgery that the reader is referred to the popular works on that branch of medical science for the methods usually employed in these cases.

### Of the Poison of Hydrophobia.

Hydrophobia is a simply contagious disease, originating in certain animals, and propagated by their bite. The action of this poison is principally on the brain and eighth pair, causing a peculiar dread of swallowing fluids, which is the characteristic symptom of the disease. Fifteen deaths from this cause are reported to have occurred in England and Wales in the year 1830.

Much speculation has been entertained, whether hydrophobia is of such antiquity as to be mentioned in the writings of Homer; but all authors are agreed that it was known as a disease affecting both the human subject, and also animals, to Aristotle, and subsequently to Celsus, to Pliny, and to Galen.

*Remote Cause.*—Hydrophobia originates in animals of the canine and feline races, as the dog, the fox, the wolf, the jackall, and the cat, probably from atmospheric causes, but from what peculiar source is altogether undetermined. It is, probably, at all times to a certain extent endemic, and occasionally epidemic among these animals. It has been supposed that it is excited in them by the great heat of the dog-days, or by the æstus veneris; but Troillet has shown that canine madness occurs with nearly equal frequency in winter, spring, summer, and autumn. The poison is not peculiar to any country, for hydrophobia is found equally in Europe, Asia, and America; neither is it limited to climate, since it prevails in the frozen regions of Canada, as well as in the East and West Indies. The difficulties attending the origin of this poison are at present not to be surmounted; but hydrophobia once originated in the animals that have been mentioned, they have the power of producing it by their bite, not only in each other, but probably in all warm-blooded animals, certainly in all domesticated animals, as the horse, the elephant, the sheep, the ox, even in the common fowl, and also in man. Happily, neither man nor any of those animals who are only liable to it in consequence of inoculation by the poisoned bite, are capable of further propagating the disease. It will be necessary, to the proper understanding of hydrophobia, to give a short outline of it as it occurs in the dog, so constantly associated with us in domestic life, and the principal source of the disease in the human subject.

The symptoms of this formidable affection, as witnessed in the dog, are some singular departure from his ordinary habits, such as picking straws or small bits of paper off the floor, and swallowing them, also licking the noses of other dogs, or other cold surfaces, as stones or iron. Besides this, he is observed to be more lonely, shy, and irritable; is less eager for his food, or refuses it altogether. His ears also, and his tail, drop; his look is suspicious and haggard; and sometimes, from the very commencement, there is a redness and watering of the eyes. In a short time saliva begins to flow from his mouth, he "slavers," and his fauces are said to be inflamed, and he is feverish. The animal, though highly irritable, and easily provoked, still obeys the voice of his master, and it is remarkable, says Mr.



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Youatt, "that the dread of fluids, and even the sight of them, so striking a feature in man, is often wanting in dogs and other animals, for many dogs lap water during the disease." In many dogs the symptoms never rise higher than these, but in others there is a repugnance to control, and a readiness to be aroused to extreme rage on the appearance of a stick, whip, or other instrument of punishment, or on any attempt at intimidation, which strikingly characterizes the disease. Even in this state, however, he seldom fights a determined battle, but bites and runs away; still even this mitigated irascibility usually ends in indiscriminate aggression, till at length he dies, and apparently of convulsions.

Examination of the dead body has often shown that the animal has died from mere nervous excitement and functional derangement; for Majendie has inspected the hydrophobic dog, and found nothing. In all cases, however, in which the poison has had time to set up its specific actions, the principal lesions of structure are found to be in those parts supplied partially or entirely by the eighth pair; for the tongue is swollen, the fauces, the salivary glands, and the angle at the back of the larynx behind the epiglottis, is also occasionally inflamed. The bronchial membrane is also occasionally inflamed, and so is also the mucous membrane of the stomach, which generally contains a strange mixture of straw, hair, hay, horse-dung, and earth, showing the peculiar morbid propensity of the animal; or being void of those substances, contains a fluid resembling the deepest coloured chocolate. Such are the symptoms and phenomena of hydrophobia in the dog, the chief source, perhaps, of this fatal malady to the human race.

*Predisposing Causes.*—The susceptibility of the human subject to this poison is by no means universal, for only ninety-four persons died of one hundred and fifty-three bitten, making the chances of escape as three to two nearly. It has been thought this occasional immunity does not arise out of any want of susceptibility to the action of the poison, but from the party having been bitten through his clothes, and the dog's tooth, consequently, having been wiped clean from all venom. Menières, however, says he met with seven cases in which the dog must have bitten through several folds, and yet they all proved fatal; showing, as he imagines, the little importance of dress as a protection from this malady.

Neither age nor sex are exempted from hydrophobia, for the infant at the breast, as well as a man aged seventy-three, have equally died of this disease.

*Contagious.*—The proof of this law is, that no instance is known of man being affected with hydrophobia, unless antecedently bitten by a rabid animal, capable of communicating the disease.

It is a question of much moment, whether the saliva of a patient labouring under hydrophobia will or will not communicate the disease. It may be stated as an undeniable fact, that during the many hundred years hydrophobia has been studied, that no instance is known of this disease having been communicated from one human being to another, although many instances have occurred of the attendants having been bitten, or otherwise accidentally inoculated with the saliva of the hydrophobic patient. The only instance which makes this law at all questionable is a case given by Majendie, in which he inoculated a dog with saliva taken from a diseased patient, and the dog shortly afterwards died of hydrophobia. But the previous state of the health of the animal had not been ascertained, and as all similar experiments made to prove this fact had failed, it may be presumed that had greater precaution been used, no such sinister accident would have resulted.

*Fomites.*—The dog's tooth is distinctly a fomes.

*Co-exists.*—No instance illustrative of this law at present exists.

*Modes of Absorption.*—This poison is probably absorbed equally by the cutaneous and mucous tissues, but probably an abrasion is necessary. The ancients were aware of this, for Celsus observes that the integrity of the lining membrane of the mouth is necessary to the operation of the psylli, whose office it was to suck out the poison after the bite of a rabid dog; and Dioscorides expressly orders them first to wash their mouths with astringent wine, and afterwards to lubricate the cavity with oil. With regard to dogs, Mr. Meynill observes that "such of them as have been thought to become affected merely by the contagion of the same kennel, will generally be found upon minute examination to exhibit the marks of bites, though concealed by the hair." When a scratch or other abrasion exists, a rabid dog merely licking the part is sufficient to infect the patient.

*Period of Latency.*—In the human subject, after the poison has been absorbed, it lies in latent combination with the blood from a few days to twelve or more months, the average period being about six weeks. At the Veterinary School at Alfort, it is the practice, when a dog has been bitten, to chain him up for fifty days, and at the end of that period, if he continues in health, he is restored to his master, not that he is now considered as absolutely exempt from danger, but that his chances of escape are greatly increased.

*Pathology.*—The theory of this disease is, that the poison is absorbed and infects the blood, and that after a period more or less long, produces functional derangement of the brain and nervous system, and subsequently organic alteration of the structures principally supplied by the branches of the eighth pair.

The action of the poison in the first instance is on the œsophageal branch of the eighth pair, producing that derangement of function which gives rise to the characteristic symptom of the disease, or to the extreme difficulty of swallowing, especially of fluids; while the spasmodic catching of the breath, consequent even on touching the lips with any liquid, proves that the recurrent nerve is equally affected. Subsequently, the eye and ear become distressed by every ray of light or impulse of sound, and likewise the sense of touch is most painfully excited, on the slightest breath of air passing over the surface of the body, all of which distinctly show that the central and spinal nerves must be functionally affected. In a still more advanced stage, the suspicion, the irritability, the violence, and generally the outrageous and uncontrollable derangement of mind which often seizes the patient, bringing on epilepsy and convulsions, show that the brain itself in likewise a principal seat of the action of this terrible poison. These symptoms are often so violent as to cause the death of the patient; and the bodies of many persons have been examined, in whom not a trace of inflammation or other morbid phenomena have been discovered; and, consequently, hydrophobia is essentially a disease of function. More commonly, however, some structural alterations have been found limited to slight inflamma-

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tion of the brain, the chord, or of their membranes, and also of the lungs or stomach, structures supplied by the eighth pair. Still the law of election prevails in this disease, and the brain, the lungs, or the stomach, may be either separately or conjointly affected—facts in no degree dissimilar to what have been observed in hooping-cough, fever, and in many other diseases caused by morbid poisons.

It is doubtful, however, whether the actions of the poison end here, for in a case treated by Majendie, and prolonged beyond the usual period, suppuration of the synovial membranes of the joints took place, and produced a state of suffering remarkable even in this frightful disease, and far more terrible than death itself. Such organic lesions as have been found are as follows:—

When the membranes of the brain have been found diseased, the appearances have been great congestion, especially of the plexus choroides, also effusion of serum into the arachnoid cavity, and also into the ventricles. The brain has also in some very few cases been supposed to be harder or softer than usual, and also to have more bloody points than in health. The mucous membrane of the pharynx and œsophagus have also been met with, either greatly congested, or diffusely inflamed, as also that of the stomach, and of the trachea and bronchi. The latter also have been found covered with a considerable quantity of frothy mucus, while the pulmonary tissue has shown marks of inflammation, though more commonly only of great congestion. The salivary glands have likewise occasionally been observed increased in size and vascular. The chord has been supposed by some pathologists to be the great and specific seat of the hydrophobic poison, and its substance as well as its membranes has been found congested; but still few cases are on record in which any traces of inflammation were discoverable. This state of parts, therefore, is merely owing perhaps to the incessant violence and struggles of the patient, and might have been predicated *a priori*.

*Symptoms.*—The wound inflicted by the bite, whether neglected or dressed, generally heals up kindly, leaving a cicatrix, and for a time the patient usually suffers no other derangement of health than the depression of spirits which his apprehensions are calculated to excite. A few weeks or a few months having elapsed, the latency of the poison terminates, and the disease is formed. The course of this affection is usually divided into three stages; the first stage comprising the symptoms which precede the difficulty of swallowing; the second commences with the difficulty of swallowing, and terminates with the overthrow of the mind: the last stage embraces all the concluding phenomena.

The first stage commences in a few instances by the patient's attention being aroused by a pain felt in the cicatrix, sometimes severe and sometimes trifling, and which shoots up the bitten limb, following in general the course of the nerve towards the heart. Pain, however, is by no means constant, and is for the most part absent. In the latter case, the first symptom is chilliness, with headache, or a slight attack of fever, and the patient is more excited or depressed than usual. These premonitory warnings last but a few hours, or at most a few days; when the fatal but characteristic symptom, "the difficulty and dread of swallowing," a symptom which distinguishes this malady from all others, appears, and the hydrophobic stage commences.

The second or hydrophobic stage is ushered in with a great difficulty, if not an utter impossibility, of swallowing any liquid, a symptom which generally comes on suddenly; and such horrible sensations accompany that effort, that whatever afterwards even recalls the idea of a fluid excites violent agitation and aversion. Some patients who have been able to give some account of themselves, describe the hydrophobic sensation as a rising of the stomach, which obstructs the passage, others as a feeling of suffocation, or a sense of choking, which renders every attempt to pass liquids over the root of the tongue not only impossible, but also excites convulsive action in the muscles of the larynx, pharynx, and abdomen. In this state, says Dr. John Hunter, "the patient finds some relief from running or walking, which shows that the lungs are not yet the seat of any great oppression."

The hydrophobia, or inability to swallow fluids, is shortly accompanied by an increased flow of saliva, termed the "hydrophobic slaver." This secretion, as the disease advances, is not only copious but viscid, so that it adheres to the throat, and causes incessant spitting, and the quantity expectorated may be taken as the measure of the violence of the disease.

The aversion to fluids is no sooner established than another series of symptoms of dreadful severity, or a highly exalted state of every corporal sense, is added. Indeed it is hardly possible to depict the sufferings of the patient from this cause, for not only does he shrink at the slightest breath that blows over him, but the passage of a fly, the motion of the bed-curtain, or any attempt to touch him, produces indescribable agony, almost amounting to convulsions. The sense of sight is no less a source of terror than that of touch, for the approach of a candle, the reflection from a mirror or other polished surface, occasions the same distressing effect. The hearing is also as strongly affected as the other senses, so that the least noise, and especially that of pouring out fluids, throws him into a fearful paroxysm. One of the dressers who sat up with a hydrophobic boy, making water within his hearing, threw him into a most violent agitation. The degree to which this painful state of the senses exists may be understood when it is stated Majendie gives the case of a deaf and dumb child, who heard distinctly in this stage. The patient, thus incessantly harassed and pained by every circumstance around him, becomes peevish and irritable, and at length sees his family, relations, and strangers, with feelings of dislike and aversion, and sometimes apparently with horror.

The third stage commences by the cerebral functions becoming disturbed, the mind being either filled with dreadful apprehensions, or else being so completely overthrown, that paroxysms of furious insanity, or fits of epilepsy, follow. In this stage horror is strongly depicted on the countenance, every symptom is aggravated, the saliva grows thick and ropy, while the poor sufferer, not daring to make the slightest attempt to swallow, spits it out incessantly, oftentimes with frequent retching and vomiting. In this state he sometimes turns black in the face, and calling out he is suffocated, falls into convulsions in which he expires, or else, exhausted by his great efforts, a sudden calm ensues, and as if nature gave up the struggle, dies without a groan.

*Diagnosis.*—When hydrophobia is fully formed, there is no disease with which it can be confounded; but

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there are many reported cases in which the imagination of a patient bitten by a dog has been so powerful as to similate the disease. In hysteria the difficulty of swallowing exists, but no other symptom.

*Prognosis.*—There is no instance of any patient or animal suffering from this disease having recovered.

*Treatment.*—As there is no well authenticated case of recovery from hydrophobia, neither is there any instance, or but rarely so, of any mitigation of the symptoms by the use of medicine. All that remains then is to mention the most leading experiments that have been made, with the hope that, as they have not been successful, they may not be repeated.

Dr. Hamilton gives twenty-one cases, and adds, many hundreds more are on record, in which venesection has been unsuccessful, though copious and often repeated. Opium has been given by Dr. Babington to the enormous amount of 180 grains of solid opium in eleven hours, without the slightest narcotic effect, or the slightest mitigation of the symptoms. Nord has given a drachm of belladonna in twelve hours, without any benefit. Dr. Atterly gave to a child eight years old two drachms of calomel by the mouth, and also had rubbed in two ounces and a half of strong mercurial ointment in a few hours, and with an equal want of success. Iron, arsenic, nitrate of silver, camphor, musk, cantharides, turpentine, tobacco, acetate of lead, cuprum ammoniatum, hydrocyanic acid, galvanism, strychnine, nitrous oxyde, chlorine, and guaco, have been also given in equally large doses, but have signally failed. These include some of the most powerful medicines in the Pharmacopœia; and, in addition to these, Ploucquet, in his *Literatura Medica Digesta*, has enumerated nearly 150 others.

The failure of every remedy by the mouth, and the powerlessness even of opium, of morphine, and of laurel water, even when injected into the veins, so convinced Majendie that, in hydrophobia, the constitution was armed against the action of any medicinal substance, that on a patient labouring under this disease being brought to the Hôtel Dieu, he determined to rely for all treatment on an injection of warm water into the veins. The patient at the time of the operation is represented as being absolutely insane, so as to require to be confined in the strait waistcoat. In this state, and with a pulse of 150, Majendie injected into his veins, in the course of two hours and a quarter, two pints of water at the temperature of 100°. At the conclusion of this operation, the pulse had fallen to 80, and the patient recovered his senses, so that the strait waistcoat was no longer necessary. The sequel, however, renders it doubtful whether this mitigation was desirable at the price of the intense suffering which followed. The poor man lived eight days afterwards, but the despondency and mental agitation quickly returned, and at the end of three days the poison appeared to set up a new series of specific actions on the synovial membranes of the wrists, elbows, and knees, attended with excessive pain, so that he was unable to bear the weight of the bed-clothes, and he died in great torture. The articulations thus affected were found on posthumous examination to be greatly inflamed, and their cavities filled with pus. This case is remarkable, as being the one in which life was prolonged for the greatest period of time recorded of this disease. The experiment has since been repeated by Gaspard and others, but the mitigation, if any, has been so slight and transient as to give no encouragement for repeating it; and tried on the rabid dog by Mr. Youatt and Mr. Mayo, it proved eminently unsuccessful.

The property which some animal poisons have of controlling and of interrupting the actions of other morbid poisons on the constitution, has caused this class of agents to be tried in the cure of this disease. The rapid and powerfully acting poison of the viper led to the hope that the bite of that reptile might prove an antidote to the hydrophobic virus, but the experiment, tried in France, Germany, and Italy, has been entirely unsuccessful. M. Grindard conceived that the vaccine virus might influence hydrophobia, and he vaccinated a hydrophobic child in three places, and afterwards injected five charges of vaccine lymph into the veins, but the child died without any marked remission, and in the usual time.

*Preventative Treatment.*—In the East Indies, after the bites of the venomous serpents of that country, the patient usually lies speechless and insensible in less than an hour. The probabilities therefore are, that unless the operation of excision, of cauterization, or of applying the cupping-glass be performed within a few minutes after the bite of the rabid animal, it is impossible to save the patient from the fatal disease, which, according to the susceptibility of his constitution, now threatens him. In all probability no prophylactic medicine exists in nature, and the exhibition of any potent substance by way of prevention is worse than useless, for without protecting the patient it injures his constitution. Mild remedies, if they tend to tranquillize his mind and to appease his apprehensions, may be innocently employed.

### Of the Poison of the Plague.

The plague is a simply contagious disease, generally marked by fever. The more specific actions of the poison are, inflammation of the lymphatic glands, and the formation of carbuncle.

Every epidemic disease of great severity, or of unusual character, was formerly termed "the plague," and considered as belonging to an order of supernatural events; as the infliction of an offended deity to punish the sins of a disobedient people. The long catalogue of calamities which history records under this name consequently embraces every epidemic disease that has fallen on man. Modern medicine, however, restricts the term "plague" to a disease of dreadful severity, and of a peculiar character, which appears to have its origin in Egypt, and in the neighbouring countries, and is unquestionably the result of physical causes.

It is impossible to determine the time when the plague first appeared in Egypt. Some writers consider it to have been coeval with Moses; while others contend that it was unknown as late as the Augustan age, and consequently is of "secondary formation." The remotest period to which we can distinctly trace it is when we find it spreading into other countries; and the plague of Constantinople, which broke out in 544, when Justinian was emperor, is the first which, from its course and symptoms, we can with certainty determine to be the plague of modern times. It was so severe that at one period ten thousand persons are said to have died daily in that city. Procopius has distinctly traced it to Egypt, and states that it spread successively over the whole empire, making its first attacks on the coast, and then spreading into the interior. The symptoms were shivering

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and fever, at first so slight as to alarm neither the physician nor the patient, but the same day, the next day, or the day after, there appeared swellings of the parotid, axillary, or inguinal glands, with carbuncles, and sometimes gangrene, and from the more usually diseased state of the glands, it was called "pestis inguinaria." These symptoms are those of the Egyptian plague, and nobody can doubt the identity of the two diseases.

The plague, from that period, has raged at short intervals in various parts of Europe, as late as the seventeenth century, so that Sir Gilbert Blane has calculated there were no less than forty-five plagues in the seventeenth century. Fourteen of them occurred in Holland, in consequence, it is supposed, of the Dutch having engaged in the Levant trade, about the year 1612; and twelve in England, imported, as has been supposed, from Holland. The last plague which raged in either of these two countries was in 1665, or the year before the memorable fire of London. This plague was termed the "Great Plague," and spread "with such intolerable infection," that 7165 persons are said to have died in one week, while in one year no less than 68,526 died in the city of London and its suburbs alone; an immense mortality, considering the then comparatively small amount of population.

The plague is still annually epidemic in Egypt, and very constantly rages on the Barbary, Arabian, and Syrian coasts, and also at Constantinople; but has been rarely seen out of the Turkish dominions since the seventeenth century. Nevertheless it broke out at Copenhagen in 1712, at Marseilles in 1720, and at Moscow in 1771. In the present century it has appeared at some of the Russian ports in the Black Sea. In 1813 it broke out at Malta and at Gozo, when the losses it occasioned were estimated at a million sterling, and the number of victims at between 4000 and 5000. It subsequently broke out at Noja in Calabria, in 1816, at Corfu, in 1818, and lastly it appeared at Gussemberg in Silesia, in 1819.

*Remote Cause.*—The plague, and consequently the poison which it generates, has undoubtedly a very limited origin. Clot Bey indeed considers it to originate, and to be endemic, along the whole of the eastern and southern coasts of the Mediterranean; the principal centres being Egypt, Syria, and Constantinople. But most authors are agreed that Egypt alone originates the plague, whence it is imported into other countries. It seems determined also that the poison is not only generated in Egypt, but also within a very circumscribed space of that country; for Volney states that the plague in Egypt never commences in the interior, but always appears first on the coast at Alexandria, passes from Alexandria to Rosetta, and from Rosetta to Cairo; and consequently he considers that the poison must be generated in the Delta of the Nile, and this fact is confirmed by all subsequent writers.

Of all the causes mentioned by authors as originating the poison of the plague, the crowded state of the population in Egypt, their misery and insufficient nourishment, are the most prominent. Every writer speaks of their mud-built huts, of their narrow and tortuous streets, and of their habitations, whether isolated, in villages, or in towns, being surrounded in every direction with heaps of dung and other immundities. In these the Arab lives with his wives, his children, and his servants, and his domestic animals, all huddled together. "Unheard-of filth," says Clot Bey, "reigns in their infected tandis." Again, some authors have considered the pestilential miasma as a product of vegetable decomposition, favoured by the inundation of the Nile, and the heated blast of the hot Khamsin; others, that it is owing to the mud deposited by the Nile; and lastly, that it is owing to the practice of making mummies of the dead, or of imperfectly and superficially burying them. Clot Bey has examined all these causes, and comes to the conclusion that, taking them conjointly or separately, they are inadequate to account for the origin of the plague. Of the many other hypotheses imagined, the generation of a peculiar animalculæ, flying from place to place, is the most ingenious, and perhaps the most unfounded theory. All, therefore, that we can safely affirm of this poison is, that it is probably of secondary formation, has a local origin, is at all times endemic in Egypt, and every five or six years epidemic. It also appears to be to a certain extent influenced by season, the plague not spreading in any very sensible degree till December, and attaining its greatest height in June, when it rapidly declines, and is popularly supposed to cease on St. John's day.

The period of the year, however, at which the plague prevails differs in some degree in different countries; but the total duration of the disease in any country to which it is not native appears to be inconsiderable, unless kept up by a fresh importation. At Aleppo it lasted from 1760 to 1762, a period of three years. But in Malta, Marseilles, and in the western parts of Europe, it has generally subsided in about a twelvemonth.

We are little acquainted with the habits of this poison as it affects animals. Dogs are said to have died of buboes, either during or just preceding the plague season; and bile taken from a deceased plague-patient, and injected into the veins of a dog, was followed by the death of the animal. Boccaccio says he saw two pigs die of the plague in 1348; and Aubert states he was credibly informed that many oxen had died with buboes during the late plague of Alexandria. Clot Bey, however, is sceptical about all these facts.

*Predisposing Causes.*—In every epidemy there is only a certain number of persons greatly susceptible of the action of the poison, else every town or city attacked must be depopulated. The proportion of persons, however, liable to be attacked by the plague is very great, for in that of Alexandria, in 1834, it is calculated, out of 42,000 souls, 14,888 perished. In selecting, however, its victims, this poison follows the law of most other morbid poisons, attacking the poor rather than the rich,—women rather than men,—patients labouring under disease rather than healthy individuals,—persons constitutionally feeble rather than the robust, and those addicted to intemperance or other excess than those who more strictly observe the precepts of Mohammed. As to races—the Arab suffers more than the Negro, the Negro than the Turk, and, in Egypt, the Turk than the European.

*Contagious.*—The belief in the contagious nature of the plague is so general that it still continues to be the terror of Europe, and the ports of every nation are closed against a vessel supposed to have the plague on board. The facts by which this precaution is warranted are extremely striking, for every time the plague has appeared in Christian Europe the arrival of a ship on board of which one or more persons have died of the plague has been an invariable antecedent. The disease also has invariably first broken out at the port or town

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at which such vessel has arrived, and if the proper precautions have been taken, has not spread, or only in a trifling degree, into the interior of the country. The following modern examples of the plague appearing in the West of Europe will exemplify this statement.

On the 25th of May, 1720, Marseilles being healthy, a vessel arrived in that port from Seyda, in Syria, having lost seven men, during the voyage, of the plague. It was usual to send vessels and their crews arriving under these circumstances, or having foul bills of health, to perform quarantine at Jaru, an uninhabited island near Marseilles; but this precaution was omitted in the present case, and so negligent were the officers on duty, that the captain and passengers were permitted to land, and even to lodge in the city, while the crew were sent to the infirmary and allowed to associate with the persons attached to that establishment. It appears also that many contraband articles were thrown over the walls. In the midst of this free communication one of the seamen died of the plague, then the *garde de vaisseau*, then the cabin-boy and two porters, and lastly, on the 20th of June, the plague broke out in the city itself, and raged with such fury that out of a population of 90,000 souls, it was estimated 39,134 died. It spread in Provence, and caused considerable mortality in that department; but, nevertheless, it was limited to a comparatively small district of country immediately around the original focus of infection.

In the year 1743, Messina being healthy, a ship arrived on the 20th of March from the Levant, and three men having died during the voyage, the ship was put under quarantine in the harbour. Two days after the captain died of the plague, and shortly after another of the crew; when, in consequence of this, the ship, ten days after her coming to anchor, was taken to a distance and burnt, with all her cargo. Forty days after the plague broke out at Messina, when 38,000 persons are said to have died of the disorder.

In the year 1813, Malta being healthy, a vessel called the 'San Nicolo' arrived on the 29th of March from Alexandria. On entering the port she hoisted the yellow flag with a black spot in the centre, the signal of the plague on board; and the master reported two men had died on the voyage, and as he believed of the plague. The same day also there arrived two other vessels, likewise from Alexandria—the brig 'Nelly,' and the Spanish polacca 'El Dolce,' which had likewise lost some men on the voyage.

The arrival of three vessels on the same day suspected of having the plague on board alarmed the city, and the 'Nelly' and the 'El Dolce' were sent away the next day, while the 'San Nicolo,' belonging to a merchant resident in the island, was put under quarantine; and on the third day the captain was seized with symptoms of the plague, and died in thirty-six hours; and his servant was seized about the same time, and he also died. On the 16th of April following, the first death from plague occurred in the city of Valetta; and on the 3rd of July, the disease had spread so extensively that the organization of a police was begun for the purpose of isolating the city and "shutting up" its inhabitants. It is remarkable that although the plague spread to many towns or villages in the island, that no sooner was that town or village surrounded by a cordon of troops, and thus isolated, than the disease was limited to that spot, and never spread in any instance to the troops immediately without it.

It is manifest that the antecedent arrival of a vessel having the plague on board at each of the three ports of Marseilles, Messina, and Malta, and the breaking out of the disease in all those places shortly afterwards, is so remarkable that it can be only explained by admitting the connexion of cause and effect. Moreover, the fact of the plague having originated in the preceding instances from imported contagion, and not from any local influence, is demonstrated by the exemption of large bodies of persons "shut up" in the very heart of the pestilence. Thus, in the plague at Marseilles, the large nunnery of des Dames de la Visitation Sainte Marie "shut up," and, although there was an infirmary on one side, for those ill of the plague, and a burying-ground on the other, for those who died of the plague, yet all the inmates of the nunnery escaped. The Hôpital de la Charité of the same city, a sort of poor-house, making up about 300 beds, "shut up," and escaped with complete impunity; but being converted into an infirmary for the plague patients, 200 of the poor left in attendance all died of the plague. In the plague of Moscow, 1770–1771, the Imperial Foundling Hospital, containing 1400 souls, "shut up," and although more than 100,000 persons are supposed to have fallen victims to this pestilence in that city, yet, except some eight persons who surreptitiously went into the city, and were instantly separated, none caught the disease. The exemption also of the Convent St. Augustin, which "shut up;" of the town of Isola, which "shut up;" and the singular exemption of all the military, "though they surrounded within a yard or two camps and hospitals in which the plague was raging, and, lastly, were subjected to those hard duties which are known to give a predisposition to inflict on soldiers the most violent type of the prevailing disease,—but they never caught the plague at all," are further proofs that the plague was not communicated through the medium of the atmosphere.

Another class of facts demonstrative of the contagious nature of the plague is the greater number of persons attending on or in communication with the sick who fall from the plague. The French army, on first taking possession of Egypt, lost no less than eighty medical officers by the plague, an immense proportion compared with the loss of the army generally. In the English army only one in forty-eight of the army generally died of the plague, while one-half of the medical officers died. On the contrary, in Malta and in Corfu, the medical officers dressed themselves in oil-skin dresses, and, thus protected, often slept in the wards, yet not one of them was attacked by the plague. Some few persons also have ventured voluntarily to inoculate themselves with plague-matter, and these have, with hardly an exception, fallen victims to their rash experiments.

Such is a general view of the facts proving the contagious nature of the plague. It must be admitted this law is doubted by Aubert and Clot Bey; but when we find the Pacha of Egypt and his court carefully "shutting up," and that quarantine establishments are formed at Alexandria and Constantinople, it is impossible not to see that these doubts are not entertained by the higher ranks of the Mohammedans, while it is well known that all the Christians of any fortune in the Levant are such contagionists as constantly to "shut up" on all similar occasions.

*Fomites.*—By the contagion *per fomitem*, as it is termed, the plague has been supposed to spread, not

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only from person to person, but from one quarter of a town to another, and also to remote and distant countries. The following are instances of this law.

"In the plague of Moscow," says De Mertens, "the principal victims consisted of the lower order of the Russians, and these bought up everything that was rescued from the flames." When the French army was in the occupation of Egypt there were so many instances of a connected series of deaths from the transmission of a captured pelisse or other article of dress, that Bonaparte ordered all infected articles to be burnt, causing such great destruction of military appointments as to have led to many remonstrances from the officers. The experience of the British army so entirely coincided with that of the French army as to the contagious nature of fomites, that they adopted the same measures. In the plague of Malta Sir Thomas Maitland conceived that disease to have been introduced into the island of Gozo by a person released from quarantine carrying with him a box he had secured in his garden. The belief in the contagious nature of the plague is so general in the Levant, that persons "shut up" usually encage, send away, or destroy all cats and other domestic animals, which they consider as so many living fomes; and in Malta all articles of food were steeped in water for at least half an hour, the wine was delivered in uncorked bottles, and pigeons, fowls, and rabbits when sold were stripped of their feathers or skin, and every particle of hair, wool, or feathers was removed by pincers and burnt. If the dead body also be considered as a fomes, we find that at Malta the grave-diggers and the bearers of the dead suffered in a very remarkable degree. To remove any doubt that might exist on this head, two criminals that had been condemned to death were placed during the epidemy in Egypt of 1834–35 in the beds of two deceased plague-patients, and they both took the disease.

If the doctrine of the contagious nature of fomites can be considered as proved, it is important to determine what length of time the pestiferous miasmata may be preserved in an active state in the substance they adhere to, and modern experience seems to prove that the period is not long. In Egypt and Syria, the day after St. John's day, when the plague has hardly yet disappeared, the clothes of many thousand persons dead of the disease are openly bought and sold in the market-places without any apprehension of infection. Another strong fact is, that the hospital Esbekié, at Cairo, in which more than 3000 plague-patients had been treated, at the close of the epidemy, and while some plague-patients were still left in it, was appropriated to a different class of patients; and, from some neglect of the servants, these persons slept in the same beds, under the same woollen counterpanes, and with no other change than the blankets, and yet no individual caught the plague. It is singular, also, that immediately after the plague of London, "the houses," says Hodges, "which were before full of the dead, were now inhabited by the living, and the shops, which had been most part of the year shut up, were again opened;" and "many went into beds where persons had died, even before they were cold and cleansed of the stench of the disease," and yet it appears there was no evident extension of the disease. Mr. Tully states, that the experience acquired in the plague of Corfu proved that susceptible effects of all kinds can be securely purified by subjecting them to the combined or even individual action of pure air or water, and that the tents employed in the plague-camps, after being washed half a dozen times in salt water and dried in the sun, were delivered into his majesty's stores, and shortly after employed in the encampment of the garrison. A voyage from Egypt is evidently capable of disinfecting all fomites, for no quarantine officer of Great Britain has been infected with the plague since 1665. It almost seems necessarily to follow, that when the plague is imported into any country, the infection or contagion must be renewed by the sickness or death of some portion of the crew during the voyage.

*Susceptibility not exhausted.*—Dr. Russel states that at Aleppo he met with 28 cases of re-infection, or 1 in 157; and Clot Bey states that he and his colleagues saw many individuals perish of plague in 1834–35 who had formerly survived an attack of the disease.

*Co-exists.*—It is certain that neither the syphilitic nor any other poison, as far as is known, gives any exemption from the plague.

*Modes of Absorption.*—This poison being contagious is necessarily absorbed by the skin, and apparently without breach of surface. Many persons are supposed to have been infected by drinking out of a cup after a person labouring under the disease; and, if so, it must also be absorbed by the mucous membranes. There are good reasons, also, for believing that, being once absorbed, it must infect the blood; for the matter of the bubo is infectious, and blood and bile injected into the veins of dogs have destroyed those animals. Another circumstance also which seems to prove the infection of the blood is that pregnant women attacked with plague almost always abort, and, according to Dr. Russel, some of the children have borne evident marks of the disease; while there is no instance of a child born of a plague woman surviving delivery more than a few hours. Clot Bey, however, inoculated himself, and also many dogs, with blood taken from the heart or large vessels of patients deceased of plague, and these all escaped infection, a result perhaps owing to the extremely minute quantity and diluted state of the poison.

*Period of Latency.*—The period of latency is a question of great moment in treating of the laws of the plague, as being that circumstance which ought to determine the length of quarantine for the person. Dr. Russel states he has known persons long shut up taken ill almost immediately, or in a day or two after coming out of confinement. Aubert also gives the case of a Maltese who was taken ill on the second day after his arrival at Alexandria. The minimum period of latency, therefore, is short. As to the maximum period, Dr. Russel says, "I met with no instance of the disease discovering itself later than the eighth or ninth day." Aubert and Clot Bey seem to have adopted the same opinion. Father Maurizio extends this period to fifteen days; Sir James M'Grigor to seventeen days; while M. Bertrand, from his observations during the plague at Marseilles, places the extreme period at thirty-five days. It is probable, however, that there must be some error in this last observation, and, consequently, that the extreme periods of latency may safely be stated to be from a few hours to twenty days.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, and after a given period of latency produces certain specific actions, which are either preceded, accompanied, or followed by fever. The more specific actions of the poison are an inflam-



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matory state of the brain and its membranes, similar to that of continued fever in this country; also a singular enlargement of the heart, the liver, or of the spleen. But the most constant action of the poison is on the lymphatic system generally,—the cervical, inguinal, axillary, and mesenteric glands being for the most part found enlarged or otherwise inflamed, and thus give rise to the characteristic bubo. The cellular tissue also appears to be often the seat of a specific action of the poison, it being frequently affected with carbuncles; every organ and tissue of the body is likewise covered with petechiæ, and often the seat of hæmorrhagic effusion.

The extreme danger attending posthumous examinations, and the prejudices of the Mohammedans, long prevented our possessing any satisfactory data respecting the pathological phenomena of the plague; but a commission appointed by Mohammed Ali in 1834-35, and consisting of Clot Bey, Gaetani Bey, Lachesi, and subsequently of Bulard, examined the bodies of sixty-eight persons deceased of the plague, and the following is a summary of the results.

On removing the cranium the sinuses were found filled with black blood, the arachnoid veins greatly injected, and the arachnoid cavity often infiltrated with serum, and occasionally with a trifling effusion of black blood. The substance of the brain was generally less consistent than in health, and sprinkled with more bloody spots than usual. The bronchial membrane appeared sensibly inflamed, although during life the patient had presented no catarrhal symptoms. The pericardium frequently contained a reddish serosity. The serous membrane, also, covering the heart and pericardium was often extensively affected with petechiæ. The heart was also distended with blood, and was almost always enlarged, or from a third to a half greater than its natural size; its tissues being often pale, and sometimes softened.

In acute cases the stomach was often natural, but more commonly there was a partial redness of the mucous membrane, like confluent petechiæ; but in more chronic cases it was of a deep red or else of a slate colour. It was also often softened, the seat of superficial ulceration, especially between the folds, and in one case blood was effused. The small intestines, except being the seat of petechiæ, sometimes livid, were rarely found diseased. The ilio-cæcal valve was the only portion of the large intestines found at any time in a morbid state, when its colour was commonly livid, and sometimes ulcerated, the ulcers penetrating occasionally the appendix vermiformis.

The liver was almost always larger than natural, and loaded with blood, while petechial spots were often seen at its surface, and once a sort of pustule was seen on the edge of the right lobe, conceived by some to be a carbuncle. The gall-bladder was the seat of petechiæ, and in two cases blood was effused into the sub-cellular tissue.

The spleen was always twice its natural size, or even more, but was rarely the seat of hæmorrhagic effusion. It was also softened, and deep in colour.

The kidneys were often found immersed in an hæmorrhagic effusion into the surrounding cellular tissue. They were loaded with blood, and the pelves filled with clots. The ureters also occasionally contained blood, and sometimes the lumbar glands were so enlarged as to press upon them and to account for the suppression of urine. The bladder occasionally presented petechiæ, and occasionally the urine was mixed with blood.

Every dissection showed that buboes, wherever seated, always resulted from diseased lymphatic ganglia. These ganglia were always enlarged, and varied in size from an almond to a goose's egg. The least altered were hard and injected. In a more advanced stage, some without any change of colour, and others again as richly coloured as lees of wine, were wholly or partially softened, and some in a state of putrilage. Sometimes these glands became agglomerated and formed masses, some of which weighed two pounds, and around these agglomerations was a hæmorrhagic effusion extending into the cellular tissue. The cervical glands often became so enlarged as to form a sort of chaplet united with those of the axillæ and of the mediastinum. The axillary glands again communicated with the cervical, and with those which surrounded the bronchi. Those in the groin connected themselves in the same manner with those of the abdomen, and these might be traced without interruption through the crural arch into the pelvis and along the vertebral column. It was especially among these latter that sanguineous effusion was found in the sub-peritoneal tissue. The mesenteric glands were often so numerous that the whole of the mesentery seemed covered with them, but they seldom exceeded an almond in size.

The blood, says Clot Bey, is evidently diseased in the plague-patient, although no analysis has shown in what this alteration consists. It is stated never to be buffed; that the serum readily dissolves the colouring matter; and that the lower part of the clot is but feebly coagulated.

*Symptoms.*—The poison of the plague produces those disordered functions of the great nervous centres which constitute the phenomena of fever, either of a low or of an active character, and sometimes so severe as to destroy the patient in a few hours, and before any secondary actions are set up. "At Aleppo," Dr. Russel says, "in the most destructive forms of the plague the vital principle seems to be suddenly, as it were, extinguished, or else enfeebled to a degree capable only for a short time to resist the violence of the disease; and the form of the plague beyond all others most destructive exists without its characteristic eruptions, or other external marks considered pestilential. These perished sometimes within twenty-four hours."

In milder cases, the fever, of greater or less intensity, is preceded, accompanied, or followed by the secondary actions that have been mentioned. The order of the occurrence of these secondary actions, and the frequency of their accession, is not determined; but buboes, carbuncles, and petechiæ are considered as the characteristic and most frequent symptoms of the plague. Desgenettes thought the symptoms presented three degrees of intensity; so also does Aubert; and this division is also adopted by the *Commission*. The first degree being a slight fever without delirium or buboes; the second degree being fever with delirium and buboes; the third degree, high fever, high delirium, buboes, carbuncles, and petechiæ.

The manner in which the plague attacks is very various. Many instances are given of patients being most suddenly seized, as when conversing, eating, walking, going to bed, or during sleep. Clot Bey, however, thinks cases of this description to be exceedingly rare; more commonly, he says, the disease is preceded for a

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Elementary Principles of Medicine.

greater or less length of time by "lassitude, loss of strength, general uneasiness, and mental anxiety, to which soon succeeded shivering, headache, vertigo, and vomiting; then appear the general and local phenomena, and among them bubo, carbuncles, and petechiæ, preceded or followed by delirium or coma, too often terminating in death."

The *first degree* of the plague is when the symptoms have presented only a slight fever, frontal headache, an altered countenance, nausea, and perhaps vomiting; or should this fever be accompanied by buboes and carbuncles, either simultaneously or consecutively, the buboes always terminate by resolution, suppuration, or induration, while the carbuncles, more or less numerous, are always superficial. In this variety the patient rarely keeps his bed, perspiration is readily excited, and the termination is never fatal. This form is common at the height of the epidemy, and is still more so at the decline of the disease.

In the *second degree* of the plague the patient staggers as in drunkenness, has a stupid air, an injected eye, an embarrassed speech; this is accompanied by nausea or vomiting of bilious matters, and often by diarrhœa, while in the last stage the matters vomited are black. There may or may not be heat of the skin; but the pulse is frequent and concentrated, and the delirium tranquil or agitated. The tongue, at first moist, is often white at the centre and red at the edges and tip, but on the second or third day it becomes dry, black, and chapped at the centre, while the teeth are covered with sordes. The secretion from the kidneys also is affected, the urine being always high coloured, at times sanguinolent, small in quantity, and, towards the termination, often suppressed. From the second to the third day buboes appear in the axilla, groin, or neck, and more rarely in the ham, and about the same time carbuncles and petechiæ, and on the fourth or fifth day, in unfavourable cases, the patient dies comatose. The patient, however, may recover, and the convalescence may be either rapid or prolonged. In the former case, about the fourth or fifth day, the tongue again becomes moist, the skin open, the pulse softer, and the buboes either terminate by resolution, suppuration, or induration; the carbuncles, when they exist, limit their ravages, the petechiæ disappear, and about the sixth or eighth day the patient is convalescent. In cases more severe the black tongue and all the other symptoms continue, the buboes are slow to suppurate, their pus is serous and fœtid, and convalescence is not established till the fourteenth to the twentieth day, and during this protracted struggle the patient often sinks. This is the form of plague which predominates at the height of the epidemy, and gradually disappears as it declines.

In the *third degree* every symptom is increased; the hebetude and dulness is accompanied by an almost entire annihilation of the intellect, and by a prostration of strength so extreme that an upright posture is impossible. The pulse, moreover, is small and frequent, the tongue moist, thick, and purple, the petechiæ of a dark colour, and the patient often dies in 24 or 48 hours, comatose, livid, and without agony. If, however, the disease should be still further prolonged, the pulse rises, the tongue is red and dry, the skin hot, the eye injected, and the countenance animated; and towards the third day an eruption of buboes, and occasionally of carbuncles, follows. The patient has now a chance of recovering, but such a result is rare. It is in this variety that buboes and carbuncles are sometimes altogether wanting; and this is that terrible form which prevails almost exclusively in the first month of the epidemy, and is occasionally met with till its termination.

The bubo seldom maturates till the fever is on the decline, which rarely happens till the eighth or ninth day, nor are they ripe for opening till between the fifteenth and twenty-seventh day. In general, says the Commission, suppuration has not been so frequent as resolution, and never were they seen to be gangrened. Aubert considers the bubo as of good augury for the patient, and its suppuration as the sign of his recovery.

The carbuncle is by no means of constant occurrence. Dr. Russel having found it only in 490 cases out of 2700. It appears, says Clot Bey, more commonly in the middle or towards the decline of the disease. Hardly any external part is free from them, not even the penis, and in one instance a carbuncle formed in the throat, which was fatal. They occur more particularly on the limbs, and more especially on the legs. In some cases they form on the cheek or lips, and by the tumefaction they cause give to the face a hideous aspect; in others the whole of one side of the jaw has been laid bare, while in others they have formed on the eyebrow and on the eyelid, and partly destroyed the eye. Clot Bey, however, observed they never formed on the scalp, the palms of the hands, or on the soles of the feet.

According to Clot Bey there are three different varieties, and all commence in the same way, or by a small red pimple, which increases, and in the centre of which a vesicle forms, containing first a yellow and afterwards a blackish serum. In the most benign the vesicle bursts and dries up in three or four days from its first formation, the epidermis alone having been infected. The second variety involves the whole thickness of the skin, as well as portions of the cellular tissue, which is moderately tumefied, and surrounded by a dark red areola. The gangrene in this form is circumscribed, and there results an eschar from one to two inches in diameter, which is detached by suppuration, leaving an ulcer with a sharp perpendicular edge. In the severe forms the redness and tumefaction cover a large space, and the gangrene rapidly involves the skin, the cellular tissue, and sometimes even the bones. It has been observed that the malignity of the carbuncle is in the direct ratio of the severity of the disease, but their mere existence is not of unfavourable augury. Their number is very various, sometimes only one, at others ten or twelve, and Clot Bey gives a case in which more than thirty formed on the thigh and leg, but they were all benign. When there are several they often form in succession. These tumors are often very painful, and Aubert mentions one seated on the back of an Arab soldier four inches in diameter.

Petechiæ are observed in some seasons and not in others. They present their different shades of colour according to the intensity of the disease, or rose-colour, violet-colour, or black. Aubert considered their appearance an almost certain sign of death. The duration of this disease is from a few hours to 15, 20, 30, or even more days.

*Diagnosis.*—Clot Bey says the diseases which most resemble the plague are typhus, severe forms of paludal fever, apoplexy, dysentery, parotiditis, and scrofulous or syphilitic affections of the ganglionary system.

*Prognosis.*—Desgenettes calculated that not more than one-third of the French soldiers attacked with plague



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recovered. In the plague of Marseilles 40,000 are said to have died out of a population of 90,000. At Malta, dividing the months of July, August, and September into two equal parts, 90 in 100 cases died in the first half, and 60 in 100 cases in the second half. At Alexandria, in 1834-5, out of a population of 42,000 persons, 14,000 are supposed to have perished. Clot Bey estimates the whole mortality for Egypt in that year to be as one in three of those attacked.

Many instances are given of a patient apparently convalescent, and even walking about, dropping down and expiring; but in general, says Clot Bey, cyanosis and partial coldness of the extremities, petechiæ, and the subsidence of the buboes were the grave symptoms. Pregnant women always aborted when seized with the plague, and all those near their time invariably died, and that even when the loss of blood has been inconsiderable.

The favourable symptoms are a quick re-action, abundant sweats, and the suppuration of the buboes.

*Treatment.*—In the treatment of the plague neither the practice of the French or English medical officers serving in Egypt has led to any happy result. The French first tried rubbing the body with oil in the manner so strongly recommended by Prosper Alpinus, but their frictions only added to the anxiety and apprehension under which the patient laboured. Cold affusion was then tried, but it caused hæmorrhage; mercury produced diarrhœa; to scarification succeeded gangrene; and to actual cautery increased debility. Bleeding was likewise tried, but was altogether unsuccessful, so that the French medical officers, baffled in every attempt at heroic treatment, at length confined themselves to watching the disease and palliating symptoms, giving antimony on the accession of the fever, and opium in diarrhœa, while they supported the patient afterwards by camphor, æther, bark, or wine.

In the British army a variety of similar or other modes of treatment were tried, but with an equal want of success. Dr. Whyte relied on the lancet, but every one of his patients are stated to have died. Some gentlemen attached to the Brunonian treatment, kept their patients under the influence of wine and opium, but this practice was so little successful that it was abandoned. Mercury and nitric acid were thought more favourably of, but mercury was only useful when it affected the mouth, and it was a general remark that the gums were unusually insensible to the action of this mineral in the plague.

It is to be regretted that recent experience has not in any degree advanced the successful treatment of the plague. "In the beginning of the epidemy," says Clot Bey, "when the morbid cause acts with a rapidity so great that some hours are sufficient to compromise the life of the patient, every treatment, even the most energetic, is powerless to arrest the course of the disease. When, however, the intensity of the disease abates we may hope for the recovery of the patient." Many will attribute this happy recovery to nature, but it can hardly be denied that nature may be greatly assisted by art. But what are the means to be adopted? This question is most embarrassing, for, consult 20 different practitioners, and each will recommend a different treatment. One relies, for instance, on narcotics, another on stimulants, a third is the exclusive partisan of bleeding, while a fourth cures all his patients by purging, or vomiting, or both. The *Commission* state, "We believe every therapeutic means to have been absolutely useless in the plague, but that under the antiphlogistic treatment the largest number recovered."



The treatment of the *bubo* was first attempted by actual cautery or a blister, but the *Commission* appear to have abandoned this mode of treatment, and to have applied emollient poultices as a mode of favouring suppuration and of mitigating pain. As soon as matter was formed they immediately opened the tumor.

The treatment of the *carbuncle*, when benign, was also by poultices. If, however, the slough was deep the part was cauterized down to the living flesh. When the mortification was of great extent, a circular incision was made in the integuments immediately round the tumor, and an iron heated to a white heat was introduced into the furrow. The subsequent dressing was lint steeped in the chlorides, and when the part granulated up it was then dressed with a compress.

*Dietetic Treatment.*—The diet to be observed in the cure of the plague is very imperfectly laid down by the different writers who have treated on the subject; but no doubt it must be the same as that observed in other febrile disorders, or that the patient should rigidly abstain from all animal food and limit himself to slops and a strictly vegetable diet.

*Preventative Treatment.*—The preventative treatment may be divided into the measures necessary for the protection of the attendants on the patient; into those which are necessary to prevent the introduction of the plague into any given city; and lastly, into those which should be adopted supposing that disease to have broken out in any town, city, or camp.

The only mode of preventing personal contamination is for the attendants on the sick to clothe themselves in oil-skin dresses, and to avoid all direct contact with the patient or with any article, whether of linen or of any other kind, that he may have touched, or which has been in any way in contact with his person. The atmosphere of a plague hospital was found, both at Malta and at Cephalonia, to be so little noxious that the attendants slept in the wards with impunity, provided they secured themselves from all personal contact.

As to preventing the introduction of the plague into any city to which it is not native, it must be admitted there is no other safeguard than quarantine, and the length of the quarantine should be the longest period of latency, *plus* the time it takes to overhaul the cargo. The longest period determined by Sir James M'Grigor for the latency of the poison is 17 days, while the time taken to unload the cargo may be estimated about four to six days, making the longest necessary period of quarantine to be 21, or at most 24 days.

When the plague has broken out in any city, experience has shown that no half measures are of any avail; that there is no middle course between allowing the disease to take its course and adopting the complete system of isolation followed in Malta in 1813. The mode in which this was effected is as follows: On proclamation of the plague existing, the gates of the town were shut, public business of every kind suspended, the population required to repair to their respective homes, and no person was now allowed to move out except especially employed on the public business. After this the town was divided into small districts (at Valetta there were 24), and a corps of volunteer guards was organized, by the inspector-general of the police, out of the inhabitants. The duty of this corps was, not to move

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out of their own streets, but to do duty at the doors and windows of their own houses, and thus to prevent all improper communication, and to see that all susceptible articles of food were immersed for half an hour at least in water; that pigeons, rabbits, and fowls were stripped of their feathers and skins; that wine was received in clean uncorked bottles; that all susceptible articles were carefully examined, and all filaments of wool, thread, feathers, &c., removed, by pincers and burnt; that all coins were passed through vinegar; and that all contact with porters, carriers of provisions, or other persons, was carefully avoided. Besides these guards, one deputy and one clerk were appointed to each district, and such a number of sick-searchers and police serjeants as might be required. The duty of the deputy, with the aid of his clerk, was to make out an accurate return of the whole population within his district, and to take care that at the door of each house a list of all persons residing there was affixed, and which list was to be corrected weekly, and a copy thereof regularly transmitted to the inspector-general. It was also the duty of the deputy to call forth the inhabitants of such houses to see that they were in perfect health, and to make a report every three days where no case of sickness occurred, but when such case did occur to make his report instantly to the inspector-general, who was to communicate the intelligence to the proto-medico, that necessary measures might be taken for ascertaining the nature of the complaint. If the disease on investigation was declared to be the plague, the parties infected and the parties suspected were equally sent to the lazaretto, taking with them such articles of value or of furniture as they might wish to save; and the moment they were removed the whitewashers and expurgators, preceded by beat of drum and sound of bugle, so as to warn all parties of their approach, marched to purify, expurgate, and to whitewash the infected house; and in order that there might be no concealment, it was ordered that on no account whatever should a corpse be interred without an antecedent medical examination directed by the proto-medico.

It is hardly possible to conceive that any community, unless strongly persuaded of the contagious nature of the plague, could submit to a system of discipline so severe, and which can be regarded as an evil only inferior to the plague itself.

When the army was in Egypt a minute inspection was made of every corps and of every department twice a week, and any person with the smallest appearance of ill-health was sent to the hospital; also every corps or hospital where a case of plague had appeared was put into a state of quarantine, and of such corps an inspection was made by the surgeons at least two or three times a day, and every case with suspicious symptoms was ordered to the observation tent or room, and on the plague appearing, such case was immediately sent to the pest-house. The men were likewise ordered to bathe frequently, and their clothes and bedding to be frequently washed and baked, while the quarters of the army were frequently changed.

Such are the preservative measures which have been raised as a barrier against the introduction of the plague into Christian Europe. "The dread of contagion," says Dr. Russel, "neither can nor ought to be eradicated from the mind of man."

### Of the Poison of Farcinoma.

The horse, the ass, and the mule are liable to a disease termed the glanders; it occurs under two forms, or the glanders and the farcy. Many veterinists have considered these varieties to be distinct diseases, but numerous experiments have demonstrated that they have their origin in one common animal poison. It appears, however, that there are several grades or varieties of both these diseases. Thus, if glanders be defined to be a fever with a running of matter from the nose, farriers distinguish three kinds: one consists of ecchymosis and gangrene, principally of the pituitary, tracheal, or bronchial membrane; another of a pustular eruption of the same parts followed by ulceration; while a third is a combination of these two forms of disease. Of farcy also there are two kinds, or the *bud farcy* and the *button farcy*. The bud farcy consists in the formation of a number of tumors on different parts of the body, as on the head, neck, and extremities, and particularly on the hinder ones, these tumors being formed not only by enlargement and inflammation of the glands, but also of the cellular tissue, and which, at the end of four or five days, soften and ulcerate. Similar tumors are said to form also in the substance of the pituitary membrane, which quickly suppurate and cause death. The button farcy is an inflammation limited to the lymphatic glands and vessels, without involving in any considerable degree the cellular tissue. It usually commences in the hinder extremities, causing lameness and enlargement of the limb; and when the valves of the lymphatics become thickened it forms a tumor called the "farcy bud," while, if the lymphatic vessel itself be inflamed, it is termed "farcy pipe."

The affections which have been mentioned have been supposed to be peculiar to the monodactyles; but it has been determined by a number of severe accidents occurring to persons employed about glandered horses, that the poison producing them is capable of being transmitted from the horse to the human subject, and again from the human subject to the horse, and to the ass, and there is reason also to believe that it is capable of being transmitted from one human being to another. The attention of the profession was first called to this interesting subject by Mr. Muscroft, in the Edinburgh Medical and Surgical Journal, in the year 1821, where he relates the case of the whipper-in of the Bardworth hunt, who wounded himself in cutting up a glandered horse for the kennel, and died at the end of a week of confirmed glanders; and two similar cases appeared in the same work about two years afterwards. These cases excited but little notice till Mr. Travers published his valuable work on Constitutional Irritation, in 1828, containing a letter from Professor Coleman on the transmission of glanders from the horse to man, and from man to the ass, together with some other cases which had fallen under his own observation. The subject was now followed up by Dr. Elliotson, in two papers in the Transactions of the Medical Chirurgical Society, narrating three cases which had occurred in his own, Dr. Roots's, and Dr. Williams's practice. At length all the then known facts were collected in an elaborate paper by Rayer, in the sixth volume of the Mémoires de l'Académie Royale de Médecine.

*Remote Cause.*—The remote cause of glanders in the horse is but little understood, but it is probably an atmospheric poison, having a peculiar affinity for the horse, and animals of his class. The glanders, however,

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when they affect the human subject, have in all instances been distinctly traced to the glandered horse as their remote cause, for no instance is known of their occurring primarily in man.

*Predisposing Causes.*—In the horse certain predisposing causes greatly favour, and are perhaps necessary to the spread of the glanders, as dirty, close, ill-ventilated stables, especially if the situation be low and damp. Horses also, when crowded on board transports, are greatly liable to this affection. Thus the Arab, in transporting his horses from Arabia to India, always chooses that part of the year when the passage is shortest, lest the accidents incident to a long voyage might oblige the hatches to be closed, and want of ventilation give rise to glanders. Bad food is also a powerful predisposing cause in the horse, especially when these animals are picketed on service, and thus exposed to the inclemency of the weather. At the close of a campaign the cavalry is often decimated by this disease, and towards the termination of the Peninsular war, the losses from this cause are said to have been enormous. The cases occurring in the human subject are too few to allow of any inference being drawn as to the influence of the predisposing causes in the production of the glanders, but they have all occurred in young men, and probably a close investigation would have shown that the habits of the patient were such as to fall within those laws which favour the production of the disease in the horse.

*Contagious.*—The general facts which establish this law in the horse are, that an immense majority of veterinary surgeons, of stable-keepers, and coach-proprietors, believe in this doctrine, and everybody must have heard this class of persons complaining, if a glandered horse has been introduced into their stables, that their stock has almost immediately fallen ill of the disease. There are few districts also in which some farmer, by the loss of a considerable part of his team, has not had sufficient proof of the contagious nature of the glanders. In this country the law is severe against offering for sale, or even working, a glandered horse, which shows that the opinion of our ancestors, time out of mind, has been that the glanders are a contagious and a fatal disease. In Germany the belief of contagion is so general that it is said the law directs any horse that has been in contact with a glandered animal shall be immediately killed. Again, Professor Coleman has produced the glanders by direct inoculation from horse to horse, so also have Professors Peal and Renault, while Leblanc assures us that he has repeated these experiments till he has demonstrated, that not only are the glanders contagious, but that the farcy and glanders are mere varieties of the same disease, the farcy matter producing glanders, and the matter of the glanders farcy.

Cases of the transmission of the glanders from the horse to man are now numerous; and that the disease is actually the glanders has been shown by Professor Coleman, who directed two asses to be inoculated with matter taken from the arm of a Mr. Turner then labouring under this disease, consequent on a puncture received in dissecting a glandered animal, and both animals died of the glanders. These experiments have been repeated with similar results by Gerard, Hering of Stuttgardt, and more recently by Leblanc, with matter taken from a patient that died glandered under Rayer, so that no doubt can exist of the fact. It seems proved, therefore, that the glanders are transmissible from the horse to man, and again from man to the ass. It has been contended also, if the glanders are transmissible from man to animals, they must be capable of being communicated from one human subject to another, and a case of this description appears actually to have occurred in St. Bartholomew's Hospital only a few months ago, when the nurse, a healthy woman, contracted the disease from a patient in the ward, and, after a short illness, died with every symptom of the glanders.

*Fomites.*—The fact of repeated inoculation with glandered virus distinctly shows that fomites may be so infected as to produce the disease. The spread of the disease also has been attributed to healthy horses having drunk out of the same pail or trough with a glandered horse, or to licking the neighbouring rack or partitions of the stalls in which a glandered horse had been placed. Mr. White attributes the occurrence of the glanders in a mare and two foals to some hay which had been left by a team of glandered horses being blown into their paddock.

*Susceptibility exhausted.*—The great fatality which has attended this disease has rendered it impossible to illustrate this law.

*Co-exists.*—The number of cases of glanders which have occurred in the human subject are as yet too few to throw any light on this law.

*Modes of Absorption.*—The farcinomatous poison has been introduced into the system both by the cutaneous and mucous tissues. Thus glanders have been produced by inserting the virus under the cutis with a lancet, and by rubbing it on the greasy heel of a horse; they have also been produced by inoculating the mucous membrane of the nose of the horse, or else by smearing that membrane with farcied matter. Farcied matter has also been made up into balls, and introduced into the stomach of the horse, and glanders have resulted. There can be no doubt, therefore, that the poison is absorbed both by the cutaneous and mucous tissues, and that being absorbed it infects the blood. This latter fact has been distinctly proved by Professor Coleman. "I have," says this gentleman, "produced the disease first by removing the healthy blood from an ass, until the animal was nearly exhausted, and then transferring from a glandered horse blood from the carotid artery into the jugular vein of the ass. The glanders in the ass was rapid and violent in degree, and from this animal, by inoculation, I afterwards produced both glanders and farcy. In acute glanders, therefore, the blood is undoubtedly affected."

*Period of Latency.*—The poison of the glanders has its period of latency, like all other morbid poisons, and that period is in general short. Two asses were inoculated by Mr. Turner, the one about a year, and the other a year and a half old, and in the first the maxillary glands became tender on the second day, and the discharge from the nostrils was established on the third. In the other the maxillary gland enlarged on the third day, but the discharge from the nostrils did not take place till the sixth day. Sometimes, however, the incubation is much longer. In the procès-verbal de l'Ecole de Lyon, a case is given of a horse which was inoculated with farcy matter, but the disease did not appear till the end of three months, and then precisely at the points of puncture. M. Gerard, an ex-veterinary surgeon of the French "artillerie de la garde," states that he introduced the matter of the discharge every

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day, into the nostrils of certain horses by means of a brush, and that the disease appeared in one on the seventh day, but in two others not till the 32od day.

In the human subject, the poison has in general been latent from two to eight days after the accident of the puncture.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, and after a given period of latency produces in slight cases an abscess at the point of puncture, followed by some tumors in the course of the absorbents connected with the punctured part. In severe cases fever is previously set up, and after this has continued for some days, there follows either a diffuse or an eruptive inflammation of the mucous membrane of the nostrils and of the trachea, terminating in suppuration, ulceration, or gangrene; also some inflammatory affection of the lung, together with the usual farcy button or bud tumors in different parts of the body.

In the cases collected by Rayer, the nose and nasal fossæ had only been examined in four cases out of fifteen, and in these there was found either ecchymosis, ulceration, or gangrene of the mucous membrane of the septum nasi, or else granules in the sinuses. The mucous membrane of the larynx, or trachea, has likewise been found studded either with the peculiar eruption, or else diffusely inflamed or ulcerated, so much so that in one case the epiglottis was in part destroyed. The lungs have likewise been found either gorged with blood, or else the seat of lobular pneumonia, or of vomicæ. In Dr. Roots's case there was an encysted abscess of the lung, which contained about two ounces of pus. Besides these affections of the more vital organs, a number of small farcy tumors have been found in different parts of the trunk, and extremities, and perfectly remote from the point originally punctured. These tumors are in different states of inflammation, some being white and indurated, others soft and injected, and others in a state of suppuration. In Dr. Roots's case, an abscess on the back of the hand communicated with the articulation of the metacarpal bones; and in another case an abscess had opened into the knee-joint. The absorbent vessels have likewise been found inflamed along the arm, from the point of puncture, and the glands to which they lead have been found enlarged and indurated, or in a state of suppuration.

*Symptoms.*—The glanders may be either acute or chronic. Acute glanders consist of primary fever, followed by local inflammation. Chronic glanders are when the local inflammation exists *per se*. The proportionate number of cases of each kind is not determined.

Acute glanders are ushered in by an attack of primary fever, with or without rigors. This is followed by pains in the limbs so severe as often to be mistaken for an attack of acute rheumatism. Some days after, the pained parts become the seat of phlegmonous tumors, accompanied with much pain, redness, and tenderness; these more commonly terminate in abscess, sometimes discharging a laudable pus, but more usually a bloody sanies, and rapidly become gangrenous. Towards the close of the disease, in 11 out of 15 cases, there has been a discharge of matter more or less purulent, viscid, and mixed with blood, from the nostrils, and in 10 of these cases the discharge was from both nostrils. The quantity, however, has in general been inconsiderable, and sometimes scarcely appreciable. The period at which this symptom appears is not constant, for it has been seen as early as the 4th, and as late as the 16th day. In the course of the disease, also, the eyelids are generally tumefied, and discharge a thick viscid matter, like that from the nose, and an enlargement of the submaxillary gland has been seen in one case.

One of the most remarkable symptoms of acute glanders in man, is the eruption of pustules on the face, trunk, limbs, and genital organs. This eruption has been compared to the varicellæ, to the small pox, and to ecthyma, but in fact is *sui generis*, and cannot be compared to any other. It has been observed to occur about the 12th day, and to be preceded and accompanied by profuse fœtid sweats. Besides this eruption, a number of black bullæ have been observed on the nose, forehead, below the ears, on the fingers, toes, and genital organs, and these have been followed by gangrene, more or less extensive and deep.

The pulse is full and quick in the early stages, but towards the close becomes rapid, small, irregular, and even intermittent. The tongue varies, as in typhus, being first white and coated, and subsequently brown or black. Diarrhœa and meteorism often complicate the disease, and black blood has been observed in the stools.

Cerebral disturbance has come on as early as the second day, but more commonly not till towards the tenth; sometimes marked by a singular want of intelligence, at others by a sinister presentiment, followed by stupor and death.

Acute glanders are rapid in their course, and two thirds of the cases have terminated before the 17th day; two have died on the 21st day, one on the 26th day, and only one has survived till the 59th day.

Chronic glanders, or acute farcy, differs from acute glanders, in the circumstance of the local lesion preceding the general febrile derangement; the introduction of the poison being followed in a few hours by inflammation of the lymphatics, proceeding from the wounded part, and extending sometimes to the elbow or axilla, and involving the axillary glands. This is followed by inflammation, and extensive abscesses in the sub-cutaneous cellular tissue, often involving the whole limb. From this state the patient may recover; but should they be multiplied over various parts of the body, and accompanied either by the pustular or gangrenous vesicular eruptions, or both, the result is generally fatal, for hectic symptoms supervene and hasten the final catastrophe.

The disease has terminated in a fortnight, more commonly has not proved fatal till the end of a month, and in cases still more chronic, a twelvemonth has been known to elapse before the patient finally recovered, or else died. Such are the general symptoms of acute and chronic glanders, as they have been observed in the human subject.

*Prognosis.*—Of 15 cases of acute glanders collected by Rayer only one recovered. Of 15 cases of acute farcy only five recovered. Of seven cases of chronic farcy only one died. Of the three cases of chronic glanders two died. The only favourable prognosis consequently is in chronic farcy.

*Diagnosis.*—"Acute glanders," says Rayer, "cannot be confounded with poisoning from puncture in dissecting or opening dead bodies;" for he adds, "out of 50 such cases reported by various authors, no mention is made in them of a discharge from the nostrils, or of a nasal or laryngeal eruption being found after death, or of

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the peculiar cutaneous eruption." Leblanc also states that he has inoculated the horse with a great number of other morbid secretions from the human subject, but has in no instance produced any disease similar to the glanders. It may for a short time be mistaken for rheumatism, but the occurrence of the secondary actions quickly dispels this error. It is perhaps impossible to enumerate every difficulty that may occur in the diagnosis, but when any doubt exists, an inquiry into the habits and employment of the party will probably solve the problem; or the inoculation of a healthy animal is an excellent counter-proof.

*Treatment.*—All the remedies hitherto tried in acute glanders have failed, for only one out of 15 has recovered, and that not from any particular treatment. Blood, when taken at the commencement, has been found buffed, and some momentary relief has been afforded, but prostration and stupor have quickly followed, while leech-bites have become gangrenous. The coming on of typhoid symptoms has caused quina, valerian, serpentaria, ammonia, and other stimulating medicines to be exhibited, but all these medicines have failed. Vomiting and purging have likewise been had recourse to; but these measures have been equally unsuccessful. It is probable, therefore, that the cure of this disease depends on the discovery of a specific remedy, and every experiment in treatment is warranted as the only chance of subduing a malady which has so constantly proved fatal. In the more chronic forms of the disease, the recovery of the patient has appeared to be owing to the excellence of his constitution, and to a generous diet, rather than to any powerful effect produced either by general or local treatment.

*Preventative Treatment.*—The prophylactic treatment is the same as that of all other contagious diseases, or carefully to avoid all contact with the morbid poison, and especially when a finger or other part of the hand is abraded; and if by accident the veterinary surgeon should inoculate himself, he ought instantly to touch the part with lunar caustic. It has been recommended, after the disease is set up, to extirpate the enlarged glands; but if there is any truth in the doctrine that the blood is poisoned in this disease, and that the local affections are the secondary actions of the poison, this practice must be as unwarranted as hopeless.

### Of the Poison of Cellulitis Venenata.

Cellulitis Venenata is that disease which occasionally affects the anatomist from punctures received in dissection, and also butchers, farriers, and cooks, in the prosecution of their business, in consequence of the dead animals with which they are conversant sometimes being in a morbid or poisonous state. This poison, however generated, being absorbed, produces inflammation, not only of the cellular tissue of the punctured limb, but often also of some remote part, as of the opposite side or arm. Dr. Collis was perhaps the first to draw the attention of the profession to this interesting subject, by the relation of two fatal cases, in the third volume of the Dublin Hospital Reports. This example has been followed by Dr. Duncan, jun., by Mr. Travers, and by Mr. Stafford. The facts thus obtained are not numerous, but are sufficient to enable us to give a slight sketch of the probable laws of this poison.

*Remote Cause.*—The remote cause is the deceased human body, or the dead body of some animal—the persons attacked, and the phenomena of the disease, plainly demonstrating such bodies, in a given number of cases, to be poisonous. It is admitted, for instance, that medical men and medical students are liable to this disease in a much larger proportion than other classes of persons; and also, that they are liable to it only while they are prosecuting their professional duties or studies. It is therefore fair to infer, that as they can cut or wound themselves with impunity at other times, that the instrument with which the puncture has been inflicted must be armed with some deleterious agent. It is not determined, however, whether this agent is always the same; also, whether it is the product of animal decomposition, or generated during the disease of which the patient has died.

There is one circumstance, however, which seems to demonstrate a given specific poison, and not a plurality of poisons, which is, that the same phenomena result, or nearly so, after the examination of bodies of patients who have died of the most opposite diseases. In Professor Dease's case, for example, the patient had died from pulmonary consumption; in Mr. Higginbottom's, of typhus. The patient examined by Mr. Blythe and Mr. Young had died of hydrothorax; while Dr. Dease and Mr. Newby were infected by opening the bodies of patients who had died of enteritis. Mr. Burton died from examining an aneurismal sac; and Dr. Kelly, Dr. Andrews, and Mr. C. Cheyne, of Leith, were all infected, in various degrees, after having been engaged in the examination of a patient on whom the Cæsarian operation had been performed.

It is usually considered that animal matter, far advanced in a state of putridity, is the cause of this disease; but experience has shown that an advanced state of putrefaction is a protection to the anatomist, and that the greatest danger is to be feared from a recently dead body; as proof of this law, the disease was contracted by Mr. Archer, a dresser of Guy's Hospital, in consequence of his examining the body of a patient who had died only the day before, and that in the depth of winter, or on the 11th of February. Mr. Dean was infected by the body of a woman who had died only forty-eight hours before, and also in February. The patient examined by Dr. Pitt had been dead about the same time, and the examination was made at Christmas. Mr. Delph and Mr. Smart were infected May 11th, by the body of a woman who had died the same morning, and was still warm; and Mrs. Hodges was infected in consequence of hanging up a piece of fresh meat. It is plain, from these instances, that the time which had elapsed from the death of the patient till the examination of the body was too short, and the temperature of the time of year too cold, to allow of rapid putrefaction.

The intimate nature of this poison is entirely unknown, and it has been stated it is questionable whether it be formed in the last moments of life, or is a product of incipient decomposition. It would appear that some bodies are more apt to generate it than others, a given body often infecting two or more persons, who have been in the habit of making posthumous examinations for years with impunity. Thus one body communicated the disease to Professor Dease and Mr. Egan; another to Mr. Hervey and Dr. Hennen, jun., and in a slight degree also to Dr. Dunbreck; another to Mr. Young and Mr. Blythe; and another to Mr. Cumming and Mr. Blythe, all persons continually practised in dissection.

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Elementary Principles of Medicine.

Some parts of the body also appear to communicate this dangerous disease more rapidly than others. The brain of the recently dead body is supposed to be extremely apt to produce it. The sero-purulent fluid also found in the larger cavities is also greatly infectious. But the most dangerous animal fluid is that contained in the abdomen after puerperal peritonitis; and also the serum found in diffuse or gangrenous inflammation. The white cancer of the liver and the substance of other medullary tumors is said to be greatly irritating. The dead bodies of animals are much less infectious than those of the human subject; nevertheless, persons who clean tripe, and horse-knackers, are said to be subject to inflammation of the hands.

It is probable that in all cases a puncture or abrasion is necessary to the absorption of this poison; but sometimes the wound is so trifling that the party infected is not aware of it, nor is any trace of it distinguishable at the time the disease is set up.

*Predisposing Causes.*—The infected person has frequently been in a state of impaired health at the time of receiving the injury, or else in a state of health, however inexplicable, which predisposes him to the action of the poison, for hundreds of punctures are inflicted with impunity for one that endangers life; and it has often happened that two persons out of three examining the same dead body have escaped, although they have received similar punctures with the suffering party. In general, indeed, the punctures, although the lancet be poisoned, are not followed by any serious accident in the strong and robust, the punctured part only slightly inflaming, festering, or becoming the seat of a small phlegmonous abscess. When the student, however, is of a feeble constitution—weakened by hard study, excess, or previous disease,—his liability is greatly increased, and the disease may assume a fearful character. The spring is supposed to be the season at which the greatest numbers are attacked.

*Contagious.*—No case is known of the transmission of this disease from one living person to another.

*Susceptibility exhausted.*—Some persons repeatedly suffer from wounds received in dissection. It is probable, therefore, the susceptibility to this poison is never exhausted.

*Co-exists.*—There is no given state of the body known to give exemption to the action of this poison.

*Modes of Absorption.*—After the examples that have been given, no question can exist about the cutaneous tissue absorbing this poison. Gaspard and Majendie have also shown that putrid matters, whether injected into the cellular tissue of the groin of an animal, or into its veins, equally produce the death of the animal subjected to the experiment. This poison, therefore, probably infects the blood.

*Period of Latency.*—The period of latency of this poison is unusually short. Thus, Mr. Elcock punctured his finger on opening a patient at twelve o'clock, and it became so painful that he showed it to Sir Astley Cooper the same evening. Dr. Pitt examined his patient at eight o'clock in the morning, and in the evening of the same day he complained of uneasiness in the punctured part. In Mr. Percival's, and also Professor Dease's case, the local symptoms were only delayed till the following morning. A longer instance of latency occurred in Mr. Newby; this gentleman opened the body of a child that had died of enteritis on Sunday, but it was not till Wednesday evening that he was laid under the full influence of this fatal poison, which in a few days destroyed him. The longest period of latency is that recorded by Dr. Spurgin, of a cook-maid, who had been practising on a stale hare, to learn the method of honing it; and a few days elapsed in this case when two slight scratches, which she remembered to have received at the time, began to inflame, and a long and severe disease followed.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, and after a short period of latency usually occasions only inflammation of the wounded part. In other cases, however, in addition to the local inflammation, a severe form of fever is added, with extreme prostration and coated tongue, and as the disease proceeds, abscesses are often formed in various parts of the body, sometimes remote from the original wound. The poison, therefore, acts locally on the punctured limb, on the cellular tissue generally, and also on the great nervous centres, producing the phenomena of fever.

After the death of the patient, in such few instances as have been examined, the cellular tissue has been found variously inflamed, the parts affected being loaded with serum in one part, with pus in another, and in a third gangrened, while the abscesses usually contain much sphacelated cellular tissue. The muscular fibre beneath the affected part has been found softened and more readily torn than usual; and in one case quoted by Dr. Duncan, both layers of the intercostal muscles were destroyed, and the ribs denuded. In some instances the muscular fibres are paler than usual, and in others darker. These phenomena have been found in whatever part the abscess may have been situated.

The axillary glands are usually enlarged and imbedded in a highly diseased cellular structure; "but although a swollen and tender state of the axillary region is one of the first symptoms observed, I have never found," says Dr. Duncan, "the glands so much diseased as to support the idea that they were the primary cause of the surrounding inflammation." The pathological states of the brain are not yet satisfactorily determined.

*Symptoms.*—Cellulitis venenata has many grades, so that it may be divided into cellulitis venenata mitior, and cellulitis venenata gravior.

In the milder forms of the disease, the wound, usually on the back or palm of the hand, or on the fingers, inflames, an ill-defined but general swelling of the finger or the whole hand follows, and this sometimes extends up the arm as high as the elbow, accompanied with a throbbing pain, and an inflamed state of the lymphatics. In severe cases the inflammation extends still higher, or to the axillary glands, so that the whole limb is more or less affected. This inflammation is commonly seated in the cellular membrane, external to the fascia, and also in the sub-fascial cellular tissue. In slight and ordinary cases it terminates in effusion of serum, which being absorbed, the disease subsides; the patient suffering, perhaps, for a few hours from a slight attack of secondary fever.

In severe forms of the disease, the inflammation spreads from the arm or axilla to the trunk of the body, as in Dr. Pitt's case, without leaving any sound interspace. The most alarming variety, however, is when the local injury heals, or only a slight inflammation, as a vesicle or pustule, forms at the point of puncture, the severe inflammation attacking some remote part, as



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above the elbow, or the axilla of the same side, whence the inflammation extends over the neck, perhaps down the sternum to the ilium, or even to the middle of the thigh, as in Professor Dease's case. In most cases these extensive inflammations have been limited to the same side by the mesial line, and only in a few instances has it passed that boundary. In other instances, as in Mr. Dease's case, the disease commenced in the left axilla, and passed to the right fore arm; and in Mr. Cumming's case it began in the left axilla, and passed to the right, where it terminated in gangrene.

The abscess which forms in the more dangerous cases is always diffuse, has no tendency to point, and is only slightly elevated above the surrounding parts, while its limits are rarely defined by a margin. Its elasticity is something between emphysema and œdema, and has been termed boggy or quaggy. If the glands likewise should be enlarged, it is only slight in degree, while no lymphatic vessel can be traced to them.

In these bad cases the inflammation runs its course, and terminates in extensive suppuration, without any redness of the skin, and perhaps in all cases the cutaneous inflammation is secondary, and consequent on the inflammation of the cellular tissue.

The pain in the swollen part is generally exquisite. In Mr. Hutcheson's case it was his chief complaint, even while there was yet neither discoloration or phlegmon. In Mr. Dease's case the pain also preceded the redness, and was almost intolerable. Dr. Pitt suffered so much as to have observed, he had never before known what pain was; and in Mr. Clifton's case it amounted to torture.

Such are the local symptoms. In a few cases the local disease is preceded a few hours by primary fever; but in the majority of cases the local disease is first set up, and the fever, consequently, is secondary; but in these latter cases the fever has often run high, and endangered the life of the patient before the local inflammation has been clearly developed. In every case the fever is typhoid in character, with great prostration of strength and profound depression of spirits. In general, however, the mind is collected and the delirium inconsiderable, or occurs only at night, or towards the close of existence. Still, there are a few cases in which it commences early, is violent, and continues throughout the disease. In several instances the skin, so far from being hotter than usual, has been sensibly colder; while the perspiration has been sometimes so fœtid as to be hardly bearable.

*Diagnosis.*—This disease is distinguished from typhus by the local affection, and from erysipelas, by the history of the case, and the existence of the intense pain.

*Prognosis.*—The great majority of these cases are slight, and are hardly a source of anxiety. In the severer forms of the disease, as a general rule, all recover when the inflammation is limited to the lower arm, and does not terminate in gangrene. A slight inflammation, also, of the absorbents and their glands is also often recovered from. On the contrary, few survive when the axilla is the principal seat of the disease, without any obvious connexion with the punctured part.

*Treatment.*—When cellulitis venenata has been of such severity as to merit a record of the case, it would appear, all theory apart, that whatever has been the mode of treatment, one-half have recovered and one-half the patients, or nearly so, have died. In the cases recorded by Dr. Duncan, jun., of Mr. Blythe and of Mr. Young, each treated as nearly similar as possible, the one died and the other recovered. Of eight cases that were bled or leeched, or underwent both operations, four died, and among them Mr. Cumming, who was bled four times from the arm, and had four dozen leeches applied. In the cases reported by Mr. Travers, Professor Dease was bled to twenty ounces, and had 100 leeches applied to the shoulder, and yet he died; while Mr. Clifton, who was bled to a still greater amount, recovered. Eight other cases are recorded that were treated by antiphlogistic medicines, by leeches, and by poultices, and of these four died and four recovered. Of two treated by tonics, one died and one recovered; while in Dr. Pitt's case the treatment was complex, and he died. It should also be added, that in almost every case calomel was used in greater or less quantity, and evidently with a most unsatisfactory result. It is plain that we at present possess no specific treatment against this poison, and the treatment will probably for a long time continue to be directed to merely relieving the symptoms; and that bleeding, opiates, and stimulants, with attention to the bowels, will long divide practitioners as to their respective merits. In the last stages of the affection, however, all perhaps will agree in the necessity of supporting the patient with wine, quina, &c.

With respect to local treatment, it may be laid down as a general principle, that, severe disease once established, a termination of the inflammation by resolution is out of the question, and that the best chance of recovering the patient is to adopt such measures as may lead to a healthy suppuration. Most authorities are agreed that leeches to the affected limb afford relief, and that their application is to be recommended, though not to such an extent as greatly to lower the patient; and in addition to leeches, that poultices should be applied to the inflamed part. Sometimes the pressure of the poultices is intolerable, and in these cases a local steam bath occasionally affords much relief. In addition to these warm applications, Dr. Lendrick recommends oil of turpentine and tinct. opii; while Dr. Osborn recommends pledgets, sprinkled with tinct. cantharidis, to be applied to the parts, and covered with the poultices. In some cases warm applications, instead of bringing relief, increase the sufferings of the patient, and then evaporating, or other cold lotions around the limb, should be substituted. When pus has formed, the propriety of making an opening is obvious.

It not unfrequently happens, however, that without any sufficient evidence existing of pus having formed, the patient is suffering most distressing pain from the great tension of the part affected, and this accompanied by a fluttering pulse, delirium, and great prostration. Under such circumstances, ought the swelling to be incised? Dr. Lendrick is of opinion, "If there be proof that the patient's sufferings are attributable to the parts being girt down by a tense fascia, there can be no doubt of the propriety of affording relief by an incision. But in the majority of cases," he adds, "the excessive pain is not referable to such a cause, and speculative incisions only increase the patient's torture; for I have been informed by patients that their sufferings, both general and local, have been increased by it."

*Dietetic and Preventative Treatment.*—In the early stages the diet of the patient should be slops and the usual antiphlogistic diet adopted in fever. In the latter

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Elementary Principles of Medicine.

stages, and after pus is formed, wine, porter, and animal food are essential to the recovery of the patient.

As a preventative remedy, Dr. Macartney recommends the punctured part to be washed with a saturated solution of equal parts of alum and nitre. The most certain preventative, however, is the application of lunar caustic to the part immediately on the injury; but it should be remembered, the caustic will be of no avail after a few seconds, or a very few minutes.

### Of the Poison of Porrigo.

Porrigo is a generic term for an eruption of psydracious pustules, usually termed *scald-head*. This disease is contagious, and has its especial seat in the scalp, but may extend over other parts of the body.

*Remote Cause.*—The origin of the poison, and the time of its first appearing, is entirely unknown.

*Predisposing Causes.*—The effects of age are very marked in the production of this disease, for porrigo is seldom seen except in childhood and in early adult age. The porrigo favosa and porrigo scutulata have been met with as early as the second or third day after birth, when the mother has been labouring under one or the other of those diseases; but the most common period is the seventh or eighth year. Every form of the disease is much less frequent after puberty, and, with some rare exceptions, is unknown in persons that are bald or advanced in life. Girls, from wearing their hair long, are supposed to be oftener affected than boys, and the feeble and scrofulous child is something more exposed to this affection than the strong and the healthy. The children of the rich, also, from their greater cleanliness and less exposure to the contagion, suffer much less from porrigo than those of the poor and indigent.

*Contagious.* — Bateman, Rayer, Willan, Mahon, Biet, and almost all writers agree, that certain forms of porrigo are contagious, although they differ as to the number of species possessing that property. Porrigo, however, is not eminently contagious, for although it often runs through schools, and is often traced from individual to individual, yet much difficulty has been found in communicating the disease by direct voluntary inoculation.

*Fomites.*—Bateman says, "This disease is principally propagated by contagion; that it is by the actual conveyance of the matter from the diseased to the healthy by the frequent contact of the heads of children, but more generally by the use of the same combs, caps, and hats;" "the multiplication of boarding-schools appearing to give increased prevalence to this disease," and the same testimony is given by Rayer, Willan, and most other writers, to the extension of this disease by similar fomites.

*Pathology.*—The theory of this disease is, that the poison is absorbed and infects the blood, and after a given period of latency produces a pustular eruption of a given character on the part of the scalp to which it has been applied, and subsequently perhaps of the whole scalp. A similar eruption sometimes appears on other parts of the body. The proof of the blood being infected in this disease is, that there have been cases in which the head has been shaved and carefully watched for many months, and each favus destroyed by lunar caustic as soon as it has appeared, yet the whole scalp has ultimately been covered with them, and, as far as could be judged, without any direct application of the poison.

Pathologists are not agreed as to the number of species of porrigo. Sauvages enumerates nine species; Willan six species; and Rayer only two species. It will perhaps be nearer the truth to limit them to four, or to the porrigo favosa, the porrigo lupinosa, the porrigo furfurans, and the porrigo scutulata. These species are distinguished by the different magnitudes of the pustules, the larger being termed favi, the smaller ones achores; also by some difference in the forms of their crusts or scabs. The frequency with which these different forms occur is not determined, but Alibert says, of the cases he treated in the Hôpital St. Louis, 90 per cent. were porrigo favosa.

The porrigo favosa, or *honey-combed* scald-head, is an eruption of the larger pustules or favi. The more recent writers have described four stages of the complaint, or a stage of vari, of pustule, of incrustation, and of ulceration.

The disease commences with a slight pruritus or itching of a few hours' duration, followed by an eruption of small red vari, sensible to the touch and to the sight. These augment in size, and before 12 hours have passed, a yellowish point forms on each of their apices, at first so small as to be only visible under a glass of considerable power, but which gradually increases, so that at the end of 24 hours it is as big as a millet seed, and this keeps gradually enlarging, till at the end of five or six days, it is of the size of a lentil. In some cases, however, they are 15 to 20 days attaining this magnitude. This pustule never acquires much elevation above the surface of the skin, and its form, according to some authors, is well-defined and regular, while others state it to be irregular and slightly umbilicated, or depressed in the centre. The peculiar matter which fills the pustule scarcely remains fluid for 12 hours after its formation, but concretes into a dry, brittle, candied, honeycombed looking scab or crust, which retains the form of the pustule, is similarly cupped or depressed in the centre, covered by the epidermis, while its under surface is marked by a small mammary process, which corresponds to the depression of the pustule. The honeycombed appearance of the scab gives the peculiar character of the disease, and hence the term "favus." The crust continues to increase, still preserving its circular form and depressed centre, till it occasionally attains a magnitude of five to six lines in diameter. When the crust is recent, it is of a yellow or fawn colour; as it becomes older its hue becomes lighter, and, as it is easily reduced to a powder, has been compared to pulverized sulphur.

The number of favi is considerable, and they commonly appear in crops, affecting the same or different parts of the head at distant intervals. They may be either distinct or confluent. When very numerous they are confluent, but the cupped form of the individual crusts may still frequently be recognized; and, according to Rayer, should this peculiar form be lost through the copiousness of the secretion, still, by removing the superficial layers, each particular favus, with its central depression, may in general be made out. At a more advanced stage of the disease the epidermis disappears, and a viscid fluid is secreted in such abundance as to form one entire incrustation over the whole head; hence porrigo larvalis, or mask or vizor-like scald-head. The smell of the scab is peculiar, and has been compared to that of the urine of a cat, or of a cage in which mice have been kept.

When a crust of recent formation is removed, a cir-



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cular depression, wider and deeper than the favus, is seen. At a more advanced stage the ulceration penetrates below the dermoid tissue. Indeed Alibert says, he has never been able to remove a crust for the purpose of making a preparation without deeply wounding the scalp, and producing considerable hæmorrhage, while in some cases a deep and extensive ulceration takes place, which has penetrated even to the bones of the cranium.

In this form of the disease the hair of the part is most commonly diseased and stands awry, and, if extracted, is found looser than natural. According to Dr. Willis, the root in the first stage is covered with a layer of white matter like coagulated albumen, and a day or two after a puriform fluid surrounds the shaft. In some cases the hair-bulb is partially destroyed, and baldness of those parts ensues; but in general, when the disease terminates, the hair, though weak at first, is entirely restored, and its colour unimpaired.

In most persons the favi occupy only the scalp; but in a few instances they form on the forehead, temples, shoulder, or fore arm. Alibert has seen them on the loins, the sacrum, the knees, and on the upper third of the leg; and Bateman has seen them on the feet and toes. It is singular, however, says Mahon, they are never found on the pubes or axillæ, a fact strongly militating against the hypothesis of the hair-bulb being the seat of the disorder. The most remarkable fact, however, is, that the nails, both of the toes and feet, have been known to be affected, being elongated and thickened; the regularity and polish of their surface giving place to longitudinal rugosities, and ultimately dividing into branches at their extremities, resembling, as has been fancifully observed, the statue of Daphne changing into a laurel. The diseased nails are not shed, but acquire an unusual sensibility; their colour is yellow, like the favus, and when cut they discharge a similar viscid fluid. This disease is said never to be cured, the nail preserving the modification which disease has imposed on it.

When porrigo forms on other parts than the head, the anatomical structure of the cutis being different, there is a remarkable difference in the severity of the disease; for the scab is very superficial, and the skin appears rather abraded than ulcerated, while the inflammation is rather diffuse than pustular.

The *Porrigo lupinosa* is an accidental variety, in which the scab resembles a lupine rather than the cell of the honeycomb, and is very rarely seen.

The *Porrigo scutulata*, so named from a shield-like appearance of the scab, like the porrigo favosa, has four stages; the first being such inflammation as causes the hair to fall off; the second is the formation of the pustule; the third is the process of incrustation; and the last is that of ulceration. The disease, however, may terminate in the first or any succeeding stage, without running through the whole number. In the first stage, the hair falls off, and the patch thus made is very generally circular or oval, its margin well-defined, and covered with scurf. When of some extent and well marked, the patch is soft, doughy, and painful when pressed upon. Some of the hair appears to be removed by the roots, while other portions are broken off near the scalp, the roots remaining. Those which remain are readily removed by friction, and if pulled have scarcely any hold of the scalp.

After an uncertain time the second stage commences by an eruption of the smaller pustules or achores. These are small yellow points, not prominent, generally traversed by a hair, much more numerous at the circumference than at the centre of the patch, and are soon succeeded by scabs, imagined to have some resemblance to a shield, which unite in such a manner as to form incrustations of the breadth of the eruption. If the pustules be left to themselves, not only do the areas of the primary clusters extend, but their edges blend together, forming extensive and irregular patches. If the progress of the disease be unimpeded, the patches may so extend, that at length there remains only a narrow border of the hair uninjured round the head. When the scabs are removed, the surface of the patch is red and shining, studded with slightly elevated points or papulæ, in some of which minute globules of pus may occasionally be seen. In some few cases extensive ulceration of the scalp takes place.

The *Porrigo furfurans*, or scurf-like scald head, is the last form of this disease, and commences with an eruption of small achores. The discharge from the pustules is trifling in quantity, and the excoriation slight. The humour, therefore, soon concretes and separates into thin lamellated scabs or scurf-like exfoliations. At irregular periods the pustules re-appear and discharge, but soon dry up and exfoliate. This form is attended with a good deal of itching and some soreness of the scalp, to which the disease is confined; the hair also either falls off, or else becomes thin, less strong in its texture, and lighter in colour. Occasionally the glands of the neck are swollen and painful.

*Symptoms.*—The symptoms are entirely local, the constitution being seldom in any degree affected.

*Diagnosis.*—A practised eye will readily distinguish these diseases from lepra, or other eruptions to which the scalp is liable.

*Treatment.*—The treatment of the forms of porrigo is not very strictly determined. Thus, in attempting the cure of porrigo favosa, some practitioners rely entirely on a constitutional treatment, as on small doses of rhubarb and soda, small doses of mercury, some preparation of iron, or else on vegetable tonics, as the inf. cascarillæ or compound infusion of gentian. Others, again, as entirely rely on a local treatment, attempting to exterminate the disease by cauterization, or else by applying some favourite ointment; and the catalogue of ointments used for this purpose includes all that have at any time been admitted into the pharmacopœia.

The best method, however, of treating porrigo favosa is to shave the head, and apply a poultice till all the scabs, or nearly so, are removed, and this being effected, the whole scalp should be anointed with the tar ointment (unguentum picis liquidæ). This ointment should be washed off night and morning with soft soap and water, and be as often re-applied. The head also should be shaved twice or thrice a week, and where there are other children, the affected child should wear an oil-skin cap to prevent the disease from spreading. This form of porrigo in the early stages will sometimes yield by washing the part with the oleum terebinthinæ night and morning, and cutting the hair close.

The *porrigo scutulata* is a disease often rebellious to every mode of treatment, but applied at a favourable moment every method succeeds. Dr. Willis has seen the disease yield to fomentations, or to bread poultices; while applying the lunar caustic round the patches about a line from their outer margin, is another favourite method. In the latter periods of the disease, Dr. Willis

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recommends "a solution of sulphate of copper, gr. vij to x. to the ounce of water; of the nitrate of silver in the same proportions: the mild ointment of the nitrate of mercury, a salve of the black sulphuret of the same metal (sulphuretum hydrargyri nigr. ʒ j. ad ʒ ij. adipis ℥ j.); the unguentum picis, an unguent of the cocculus Indicus pulveriz. ʒ j. to ʒ ij. adipis ℥ j., may be tried one after the other; and in different instances each will have the merit of the cure." "The most effectual remedy in itself is unquestionably the eradication of the affected hairs. These are to be removed singly with the forceps, not pulled out along with all the healthy growth in their neighbourhood, as used formerly to be done by the barbarous application of the pitch-cap."

This disease occurring on surfaces not particularly covered with hair yields at once to the application of a solution of sulphate of copper, or of the nitrate of silver in water.

### Of the Paludal Poison.

The marsh generates a poison which produces intermittent, remittent, and yellow fevers, and also dysentery. It will be more convenient, however, to treat first of the paludal fevers, and then of dysentery. This class of disease, so interesting to the medical philosopher, and formerly so destructive, has almost disappeared from this country, owing to the improved drainage both of the towns and of the agricultural districts, for only 95 cases are reported to have died of ague in England and Wales in 1839.

*Remote Cause.* — The facts collected by medical writers from Hippocrates downwards, show that every country is unhealthy in proportion to the quantity of marsh, or of undrained alluvial soil that it contains; the inhabitants of such districts dying often in the ratio of 1 in 20, instead of 1 in 38, the average mortality in healthy countries, and also that the diseases from which death results in these districts are peculiar fevers of an intermittent or remittent type, varying in severity according to the temperature or latitude of the place, and also dysentery. The connexion of a given class of disease with marshy districts is thus distinctly established, and the inference of necessity drawn is, that it depends on a peculiar cause, or a paludal poison generated by the marsh, and we have an endless series of instances to establish the truth of this deduction.

Ancient Rome was once the seat of so many fatal epidemics, that the Romans erected a temple to the goddess Febris. These arose from the great masses of water poured down from the Palatine, Aventine, and Tarpæian hills becoming stagnant in the plains below, and converting them into swamps and marshes. The elder Tarquin ordered them to be drained, and led their waters by means of sewers to the Tiber. These subterraneous conduits ramified in every direction under the city, and were of such considerable height and breadth, that Pliny terms them "operum omnium dictu maximum suffossis montibus atque urbe pensili subterque navigata;" and this system of drainage, which was continued as late as the Cæsars, rendered Rome proportionably healthy, and the seat of a larger population than has since perhaps been collected within the walls of any city. On the invasion of the Goths, however, the public buildings were destroyed, the embankments of the Tiber broken down, the aqueducts laid in ruins, the sewers obstructed and filled up, and the whole country being now again overflowed, Rome once more became the seat of an almost annual paludal fever, as in the times of her earliest foundation.

The insalubrity of the Pontine marshes, past or present, is notorious. Three hundred years, however, before the Christian æra, Appius Claudius drained them by making canals, building bridges, and by constructing that magnificent road, portions of which still remain, and still bear his name. This road, the "regina viarum," was the especial care of the Gracchi, of Julius Cæsar, of Augustus, of Trajan, of Vespasian, and of the Roman Emperors generally; and was that on which Horace delighted to travel on account of the number and excellence of its inns, for "minus est gravis Appia tardis." On the invasion, however, of Italy by Theodaric, Cæcilius Decius gave a free course to the waters in the neighbourhood of Rome, and the re-establishment of these immense marshes was one of the many disasters which resulted from the attacks of the Goths on Italy. Their present state is such, that the Tuscan portion of the Maremme, and indeed the whole of that district, may be said in summer to be absolutely depopulated, not a single house retaining an inhabitant, except the guard-houses, with a few soldiers and custom-house officers, and these are relieved twice or thrice during the summer with the Maremme fever almost invariably upon them.

Of modern towns that have been drained and remained healthy there are many examples. London, for example, in the time of Sydenham, was infested with epidemic intermittent fever and dysentery, the mortality from the former alone averaging, in a comparatively small population, from one to two thousand persons annually. In the present day, owing to the formation of sewers and a general system of drainage, a case of ague contracted in London is hardly known. Many other towns, both of this country and of France, as Portsmouth, Rochefort, and Bordeaux, from being the constant seat of paludal fevers, have been from the same causes rendered in like manner perfectly healthy.

The intimate connexion, therefore, between marshy districts and certain diseases is thus established by a great amount of direct or indirect evidence; the next proposition is, what is the nature of the noxious agent, and what circumstances are necessary to its formation or extrication?

It seems certain that the deleterious agent is neither heat nor moisture, nor any gas extricated from the marsh. It cannot be heat, for many of the hottest parts of the West Indies, as the sandy quais, are free from fever. It cannot be moisture, for no persons enjoy better health than the crews of a clean ship at sea, even when cruizing in tropical climates, as long as they have no communication with the land. While carbonic acid, azote, oxygen, or carburetted hydrogen, the gases collected by stirring the bottom of marshes, have all been inspired without producing any disease similar to paludal fever, and it seems consequently to follow almost as a necessary consequence, that the remote cause must be a miasm, poison, or malaria, whose presence is solely detected by its action on the human body, and two hypotheses have been imagined to account for its origin; the one, that it is a product of vegetable decomposition; the other, that it is an exhalation from the earth, favoured by the conditions of the marsh.

The general evidence in favour of vegetable decomposition being the remote cause is, that all countries are for the most part free from paludal diseases while the

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crops are growing, and ooly become unhealthy after the harvest, when large quantities of vegetable mattars are left on the ground at the time the rain begins to fall. It may be said that, except rice, we neither reap nor sow in marshes. This is unquestionably trua; but it will be seen hereafter that marshea are in general healthy till the summer's sun, or other cause, has diminished their waters, and bared a greater or less portion of their bed. Tha part thus exposed almost always contains a large portion of vegetable matters, which, runniog into rapid decomposition, generate the poison which gives origin to this class of disease.

The particular avidance of vegetable decomposition being the source of this poison is as follows:—Lancisi, for example, gives the history of an epidemic remittent, or intermittent, which for several summers infested, and almost depopnlated, tbe ancient town of Urbs Vetus, situated on an elevated and salubrious part of Etruria, and which was traced to the circumstance of the peasants steeping their flax in some stagnant watar in the neighbourhood of the town. This practice was therefore prohibited in 1705, and the epidemic ceased to appear. The apprehension of the steeping of flax being productive of paludal fever is not limited to Italy, for the ancient as well as the new "coutumes" of almost all the provinces of France have proscribed the steeping of flax, "la rouissage," even in running waters, from the fear of infection, and this prohibition forms part of the "droit public" of that kingdom. In the Netherlands also the same belief prevails, or has prevailed; for, in July, 1627, the King of Spain passed an ordinance, prohibiting tha steeping of flax in the streams and canals of Flanders.

Tha experience of the indigo-planter is to the same affect. In India, after the colouring matter has been extracted from tha indigo plant, it was formerly the custom to throw tha detritus into large heaps or masses in the immediate neighbourhood of the works, and which, at the and of three or four years, becomes manure of an excellent quality. It was found, however, that these heaps, wetted from time to time by tha heavy rains, and afterwards heated by the rays of a burning sun, rapidly decomposed, and at length emitted miasmata, which produced all the effects of those axtricated from tha marsh; for the workmen who lived near, and more especially those to leeward of these masses, were found to be very commonly attacked by fever, chiefly of the remittent type, and similar to those which prevail in the paludal districts of that couotry. This consequence is now so well established that the most intelligent indigo-plaoters no longer allow these heaps to be formed either near the works or in the immediate neighbourhood of the cottages of their workmen.

Ships also afford additional evidence of the truth of the hypothesis of vegetabla decompositiou being the remote cause. The Priamus frigate underwent some repairs at Plymouth previous to a voyage to the West Indies, but the chips and shavings, instead of being removed, were allowed to remain and to mix with the bilge-water under the limber-boards. On the voyage the fuol state of the hold was indicated by tha most offensive amells, and at Antigua a fever broke out, which daily destroyed increasing nnmbers. The true cause was not yet suspected, and a voyage was undertaken with a view of mitigating the calamity, but without success. The ship at length returned to Antigua, and the state of the hold was examined, aud of the effect produced by this proceeding Mr. Hartle, one of the medical officers present, gives the following account:—Whan the limber-boards were removed the affluvium surpassed everything he had before experienced; a boatswain looking into tha hold, fainted, and afterwards passed through a formidable attack of fever. Every individual also present likewise suffered from fever, and Mr. Hartla bimself suffered from a slight iodisposition. Although tha frigate had only been six months from England, four large mud-boats of filth were removed from her, and which lay nine inches thick in the hold. Even the negroes amployed in removing this mass were obliged to go on deck occasionally, so insufferable was the stench, and three of them had tha characteristic disease. The after magazine, immediately nnder the gun-room, was found in the worst state, and this accounted, in tha opinion of Mr. Hartle, for every officer's servant and every servant of the gun-room mess having suffered. Saveral cases occurred after tha removal of the crew, in consequence, as it was discovered, of the men having gona on board clandestinely. Tha ship having been cleansed and thoroughly purified, the general health of the crew was restored, and on their returning on board continued good.

Thesa facts render it highly probable that the noxious agent must be a product of vegetable decomposition, changed from a fixed to an aëriform state, and evolved in the lower regions of the atmosphere. But it must be admitted no eudiometry has yet been able to discover the immediate principle. The atmospheric air collected at the embouchure of the Valtellina, a country where it is impossible to sleep without being attacked with fever, gives, on analysis, the same constituent parts and proportions of gases as that collected at the summit of the Alps, or in the narrowest streets in London. Moscati has condensed the exhalations of tha marsh as they arose, by meaus of glass globes filled with ice, but these experiments hava not led to auy discovery, nor have they in tha least degree elucidated the subject.

If we consider the paludal poison to be a product of vegetable decomposition, it follows that heat and moisture, quantity of vegetable matter and nature of the soil, though not the essential agent, must have a sensible influence on its formatioo, must vary its intensity or quantity, and also must limit paludal diseases to particular localities, seasons, and latitudes. A certain temperature, for exampla, is avidently necessary to its extrication; for should the heat be excessive, the vegetable substance, rapidly parting with its juices, is dried up or charred even before decomposition commences. Thus, in all tropical countries, aven the most pestilential, tha hot seasoo is the season of health, and during the dry period of the year most parts of the country are as pleasant and healthy as any part of the wurld. But no sooner do the rains fall and the parched crust of the earth become softened, than vegetable decomposition commences, and so actively that the ground emits a most offensive stench, and a general and violent sickness follows. On the other hand, in countries of a low temperature, as towards the polar regions, the decompositiun of vegetable matter is so slow that even the marsh is healthy.

It is certaio also that a given quantity of moisture is as necessary to vegetable decomposition as a givan temperature, and that the axtrication of the paludal poison will be most abundant from that soil which contains no

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more moisture than is necessary for that process; for an excess in quantity, by dividing and separating the particles, and by preventing the access of atmospheric air, will either retard or altogether put a stop to putrescency. This law is most important, as it explains the reason why in some countries frequent and heavy rains will render marsh fevers prevalent, by saturating the whole of the open country, while privation of rain will in others produce exactly the same effect in other instances, merely by diminishing the superfluous quantity of water. Thus in the West Indies an uncommonly rainy season seldom fails, in the perfectly dry and well-cleared island of Barbadoes, to induce for a time general sickness; while at Trinidad, whose central portions are described as a sea of swamp, and where it rains nine months in the year, an excess of moisture is a preservation from sickness; for should at any time rains fall only eight months in the year instead of nine, the swamps become dry and bared to the sun, and remittent fevers of the worst kind are sure to make their appearance; and the same result follows on the subsiding of the waters of rivers that have overflowed their banks, as those of the Nile, the Rhone, the Danube, the Tigris, or the Ganges.

It is evident from these data that the swamp, on its approach to dryness, is the harbinger of disease and death, while an excess of rain is a preservative power. On the contrary, on the rich and dry plains, and even on the hills of tropical countries, rain is the cause not only of vegetable decomposition but also of disease, while dryness is the preservation of health.

In estimating, however, the dryness of a country, its superficial appearance is often deceitful. In the years 1748 and 1794 the summers were dry, and our troops took up the encampments of Rosendral and Ousterhout in South Holland. The soil in both places is a level plain of sand with a perfectly dry surface, and where no other vegetation existed or could exist but a few stunted heath-plants; yet in both years fever became epidemic among the troops in each place. On digging for water the cause was discovered, for the soil was found to be percolated with water to within a few inches of the surface. It is probable, therefore, that this country was originally formed of vegetable and other detritus, brought down by the Rhine and the Waal, and afterwards covered with sand thrown up by the sea, and which, heated by the summer's sun, became the powerful cause of the extrication of marsh miasmata. From the exceeding malignity of the salt marshes, it has been supposed that a mixture of salt and fresh water rendered a marsh more pernicious than either of them alone, on account of its destroying certain animals and vegetables that can exist only in the one or the other medium. It has been found, however, that on coasts where these marshes have been kept up to one uniform level by means of flood-gates, that the surrounding country is healthy; it has therefore been inferred that the sickness produced was a consequence of the perpetual alteration of the level of the waters of the marsh, and not owing to the admixture of sea and spring water. It is probably owing to a great excess of temperature that rocky countries, as Gibraltar and the Ionian Islands, are so often and so severely attacked with fever.

It is on the summits of these rocks that springs arise. The slightest frost produces fissures, into which mould and vegetable matters insinuate themselves, while the bare rock becomes heated to an intense degree. Humboldt, on ascending the Orinoco, found the station at the great fall depopulated by fever, which the natives attributed to the bare rocks of the rapids. He determined the heat of these rocks to be 118·4°, while the thermometer of the air immediately around was only 78·8°. Again, the rock of Gibraltar is known to be percolated with water, so that we can hardly conceive a more pestilential focus of disease, when the chemical causes necessary to the formation of miasm are combined. The existence of paludal fever in dry and rocky districts, therefore, although it may appear extraordinary and unexpected, is not necessarily an exception to the general law of paludal diseases being generated by miasmata generated by vegetable decomposition.

These facts seem, therefore, unquestionably to prove that heat and moisture, though not the primary cause of paludal disease, are conditions essentially connected with the extrication of the noxious miasmata, and consequently are a strong additional argument in favour of the hypothesis of vegetable decomposition generating the remote cause which produces them. It is certain, however, even when the conditions of heat, moisture, and vegetable matter most abound, that the paludal diseases do not always assume their severest forms: thus Jamaica is more unhealthy than Demerara, Demerara than Barbadoes; and, taking the West Indies generally, that country is more unhealthy than that of the East Indies. There must be other circumstances, therefore, affecting the problem in question; and there seems reason to believe that differences of geological formation, by favouring or otherwise influencing vegetable putrefaction, may greatly affect the health of countries similarly situated.

It is perfectly well known that different soils radiate heat with very different degrees of intensity, and consequently are, under the same circumstances, of very different temperatures, have very different powers of attracting moisture, and possibly also they may have other and more direct chemical affinities for generating or attracting the paludal miasm. Nothing, for instance, is better determined in husbandry than that the carbonate of lime, mixed with the ordinary matters of a compost, greatly forwards the processes of putrefaction, so that the mass thus prepared is fit in a much shorter time for the purposes of manure. The causes which occasion this rapid decomposition have been investigated by Sir Humphrey Davy, and he has ascertained that lands situated in calcareous districts, like the West Indies, where the surface is a species of marl a few inches deep, lying above limestone earth, are extremely hot, and attract moisture largely. No springs, it is well known, arise on chalky hills, the water being unable to penetrate so impervious a soil; yet it is of common observation that the ponds on those hills are always full. The different powers of absorption of water by different soils is often beautifully seen in this country; for the sandstone and limestone hills of Derbyshire and of North Wales, for example, may be easily distinguished from each other at a considerable distance by their different tints of verdure; the grass on the sand-stone hills being usually brown and burnt up, while that on the lime-stone is flourishing and green. Now if the difference in the absorbing powers of different soils in this country is so striking when the atmosphere contains only 1-75th part of its weight of vapour, how much greater results must arise from this difference of soil between the tropics, where the atmosphere con-

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tains three times that quantity, or 1·21st part of its own weight of vapour. It appears, therefore, there are some soils peculiarly favourable to the decomposition of vegetable matters, and consequently to the more abundant extrication of marsh miasmata; and it is remarkable that those countries most celebrated for paludal fevers have been found similar in their geological formation to each other, and to those artificial conditions which most favour rapid vegetable decomposition.

It seems probable also that the volcanic matters which enter so largely into the structure of the West India islands add to the intensity of the miasm, and thus cause the severest forms of paludal disease. It is perhaps to this cause that the severe paludal fevers which occasionally appear in the rocky and volcanic countries of Europe, as Gibraltar, the Campagna di Roma, many parts of Spain, and the Ionian Islands, are partly owing.

Of the matters evolved in volcanic eruptions, it seems probable that sulphur is the agent which, by its affinity, adds to the intensity of the miasm, for that substance appears to exist in a remarkable degree on the western coast of Africa, a spot fatal beyond all others to European settlers. An experience of between 30 and 40 years, for example, has shown that the copper sheathing of a ship will be as much or more injured in a nine months' cruize off that coast as from a similar service of three or four years in any other quarter. This circumstance induced the Lords of the Admiralty to send to Mr. Daniel, for analysis, a quantity of sea water drawn between the 15° and 16° of latitude of that coast; and that celebrated chemist has shown that it contains a considerable quantity of sulphuretted hydrogen, arising either from a soil having a volcanic origin, or else from the decomposition of the sulphates contained in sea water by the carbonaceous matters arising from the decomposition of the immense quantities of vegetable matters, which grow down even to the water's edge in that country. If sulphuretted hydrogen should hereafter be determined to be an element increasing the virulence of the disease, it will be an interesting question whether it acts merely as a depressant, or whether, by combining with the poison, it augments its intensity.

It is highly improbable we shall ever arrive at such an exact knowledge of the causes which affect the extrication of marsh miasmata as to enable us to predicate all the facts connected with paludal diseases; for the variations of atmospheric temperature, the changes in the quantity and nature of the electric fluid, the quantity of water, the nature of the soil, the amount and character of the vegetable matters, form a problem extremely complicated, and one whose smallest variation as to quantity or time may occasion marked differences in the result. As a general rule, however, it may be stated, that in no climate do paludal fevers prevail to an equal degree all the year round. In the winter much of the vegetable matter has already undergone decomposition, while the dryness of the season, and the diminished temperature, are little favourable to further putrefaction. When the spring, however, arrives, and the rain falls, and the heat of the sun increases, the earth again opens its bosom, and a miasm of mitigated intensity is again developed. In summer the products of vegetable decomposition are used up in affording nourishment to the growing crops, and this season, like the winter, is in general healthy. But in the autumn, and after the harvest has been gathered, when the ground is covered with vegetable debris, when the rain falls in torrents, and when the solar heat has acquired its greatest intensity, all the conditions of the greatest quantity of vegetable matter, of moisture, and of highest temperature are united; so that the season which realizes the hopes of the husbandman is also the period of pestilence and of his greatest danger. There are two other facts also which are too prominent to be mistaken: the one is, that the miasmata vary greatly in intensity in different countries, and also in different parts of the same country. Again, the diseases they produce, though annually *endemic* in given districts, yet become in certain years, and from the action of causes not yet determined, *epidemic*.

The proof that the miasmata vary greatly in intensity is, that paludal fevers vary in severity in different countries, and even in the same country, under different circumstances, assuming the different forms of intermittent, remittent, and yellow fever. In this country, when the summer is short and but moderately hot, the type of the marsh fevers is not usually of a dangerous character, and they are for the most part mild intermittents, only occasionally assuming a remittent form. In Holland and the Netherlands, and in the north of Germany, the intermittents are of a bad kind, and not unfrequently become remittent. In the still hotter climates of Spain and Italy, as well as in the more tropical regions, the intermittent is less common, while the remittent is frequent, violent, and not unusually assumes the form of yellow fever.

In the same countries also it is determined that difference of altitude is equivalent to difference of latitude; and, as a general law, it may be stated that in the Antilles, on the continent of America from Boston to Rio Janeiro, and also on the continents of Asia and Africa, that while in the low country severe remittent or yellow fever prevails, still in the higher country, though immediately contiguous, the type is changed to intermittents and mild remittents. The interesting fact stated by Humboldt, that the vomito prieto never appears on the table lands of Mexico, is strictly in accordance with the observations made in every other equatorial part of the world at a similar elevation above the level of the sea.

The symptoms of intermittent, remittent, and yellow fever differing in many respects from each other, it may be doubted whether these diseases arise from the same cause, differing only in intensity. The circumstance, however, of intermittents passing into remittents, and remittents into yellow fever, and conversely of remitting and yellow fever often terminating in intermittent—facts observed not only in the East and West Indies, but on the continents of America and of Africa—demonstrate an unity of cause as firmly as the best established facts in medicine.

The law that paludal diseases, like many diseases produced by morbid poisons, are annually endemic, and only occasionally epidemic, is unquestionable. A few years ago intermittent fever was epidemic in particular districts in this country, but of late years the cases of ague have been comparatively rare. In Demerara it is observed that yellow fever is epidemic about every seventh year. At Gibraltar, although sporadic cases of paludal fever occur annually, still yellow fever is only occasionally epidemic, but so irregularly, that it assumed that character in 1804, then in 1810, again in 1813 and in 1814, and from that period the garrison suffered no

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Elementary Principles of Medicine.

similar visitation till 1828. The physical causes on which this greater virulence and greater spread of the disease depends are not determined. In temperate climates it has been observed that paludal fevers have been most epidemic when a hot summer has succeeded a wet spring. In the West Indies, however, they often appear without any warning, and without any sensible change in the quantity of rain, or in the height either of the barometer or thermometer. They follow no given cause, but, like influenza or cholera, appear to be altogether the result of inscrutable influences.

Having thus stated the general laws which relate to the extrication of marsh miasmata, it is now necessary to ascertain those limits within which the poison issuing from its source may infect the human body.

*Infecting Distance.*—As a general law the danger of infection is in proportion to the proximity of the party to the marsh; but there are many disturbing causes, which produce many remarkable exceptions to this law, and render the solution of the problem one of extreme difficulty, as the extent of surface which generates the miasmata, their intensity, the direction of the wind, its force, the season of the year, the time of the day, and the attracting influence of the surface over which they pass. These data are so multifarious that it is impossible to do more than assign the most general facts, both as to the altitudinal as well as to the lateral range.

*The altitudinal Range.*—The Monte Maria, which adjoins Rome, is, according to Breyslack, about 165 yards' perpendicular height, above the Pontine Marshes, and is extremely unhealthy. Tivoli, which is about 230 yards above the level of the same marshes, is infinitely more salubrious; while at Serre, 340 yards' perpendicular height, the inhabitants enjoy an entire exemption from the paludal diseases which prevail below. In Italy it is estimated that an altitude of 1400 to 1600 feet is necessary to assure an exemption from paludal disease; but in the West Indies, where the poison is of so much greater intensity than in Italy, it is estimated that an elevation of 2000 to 2500 feet is necessary to give a similar immunity.

In towns partially freed from marsh miasmata by extensive drainage, the difference of a few feet perpendicular height makes an almost inconceivable difference in the liability of persons to paludal disease. The barracks af Spanish Town, the capital of Jamaica, for instance, consist of two stories, or of a ground floor and of a first floor; but it being found that two men were taken ill on the ground-floor for one on the first-floor, it was at length ordered that the ground floor should be no longer occupied. Dr. Cullen remarked a similar result at Portobello, Dr. Ferguson in St. Domingo, and Sir Gilbert Blane in the expedition to Walcheren. This law is so well understood in the West Indies, that in Demerara, and in many other parts, the houses are built on dwarf columns, after the manner of our corn stacks, in order that a stratum of air may be interposed between the house and the ground. In Rome, and in other towns of Italy, it is also so well known that the lower rooms of the houses are abandoned to the servants, the family occupying the upper rooms, as affording a greater protection from the paludal poison.

The *Lateral or Horizontal spread* of marsh miasmata is a problem still more difficult than that of the altitudinal range. The least complicated cases are those when water alone intervenes between the marsh and the recipient. In the year 1746-7, while our troops lay in Zealand, the sickness was so great among four battalions quartered there, that some of those corps had hardly 100 men fit for duty, or less than a seventh part of a battalion. In one corps, the Royals, only four men escaped. At the time, however, of this remarkable prevalence of fever on shore, Commodore Mitchell's squadron lay at anchor between South Beveland and the island of Walcheren, and the fever raged at both places; but nevertheless, in the midst of all the sickness that reigned around, the seamen were neither affected with fever nor flux, but continued to enjoy perfect health. These observations of Sir John Pringle were fully confirmed by those of Sir Gilbert Blane, during the last disastrous expedition to Walcheren: "I had," says this physician, "the opportunity of observing the extent to which this noxious exhalation extended, which was found to be less than was generally known. Not only the crews of the ships in the road of Flushing were entirely free from this epidemic, but also the guard-ship, which was stationed in the narrow channel between this island and Beveland. The width of this channel is about 6000 feet: yet, though some of the ships lay nearer to one shore than to the other, there was no instance of any of the men or officers being taken ill with the same disorder as that with which the troops on shore were affected." It appears, therefore, that in Europe the horizontal spread of marsh miasmata over fresh water is less than 3000 feet. With respect to the spread of the miasmata over salt water, Sir Gilbert Blane is also of opinion, that in tropical climates ships at a distance of 3000 feet from a swampy shore—a distance to which the miasmata did not extend in Zealand—and even further, were affected with the noxious exhalations. Dr. John Hunter considers a few miles to be a necessary interval for a ship lying to leeward of a swamp, in order to ensure a complete exemption from the disease. When, however, the swamp or other source of the poison is of small extent, a much less space is sufficient to assure an exemption. In the epidemic on the coast of Spain, the fisherman living with his family on board his boat has been rarely attacked, though lying at anchor close in shore. Also, during the late epidemics at Gibraltar, it was not unusual for the richer inhabitants to hire a Moorish vessel, and to live on board in the bay; and there was scarcely an instance of those persons having been affected, though keeping up a free communication during the day, either directly or indirectly, with the town. The explanation of the exemption of ships riding in rivers or shallow waters is, that the water in these situations is often much hotter than the land, or the atmospheric air, and consequently the vapour the latter contains is not condensed or deposited. In harbour, also, if the water be shallow, the same thing must take place; while in deeper water the temperature of the water is sometimes lower than that of the land, and consequently the poison is often precipitated, and at considerable distances from the swamp.

The extent to which marsh miasmata may spread from its source over land, in a horizontal direction, is a much more complicated question, on account of the different affinity which either the poison, or the vapour which it holds in solution, has for the many substances over which it passes; for different soils act as so many attracting or repelling causes, tending to limit or extend the spread of the poison. The effect of trees in intercepting the paludal poison is remarkable, and appears to have been known to the ancients, who are supposed to have surrounded their temples with groves



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on account of their protecting influence. Pope Benedict XIV. ordered a wood to be cut down which separated Villetri from the Pontine Marshes, and, in consequence, for many following years there raged throughout the whole country, and in places never before attacked, a most severe and fatal fever. The same effects were produced from a similar circumstance in the environs of Campo Santo. On the contrary, even in the West Indies, it is quite wonderful how near the marsh the planter, provided he is protected by trees, will venture to place his habitation. It is probable the immunity arises from the trees partly condensing the vapour of the marsh, and partly, perhaps, by their giving an upward direction to the current.

Different soils also act as attracting or repelling causes which affect the transmission of the paludal poison. The spot, for instance, on which the new National Dock and arsenal are built was a marsh of about 700 acres, and on either side of it are the villages of Greenhithe and of Northfleet. The peculiarity in this case is, that the inhabitants of these villages rarely suffered from intermittent fever, whilst those on the hills beyond were greatly afflicted with that disease. Dr. Maton mentions a similar fact in the neighbourhood of Weymouth, and the same circumstance is observed also in the neighbourhood of Little Hampton, and the marshy districts in Sussex.

The different force by which the paludal poison is attracted by different surfaces has often been observed in the West Indies. Fort Hildane at Porto Maria, Jamaica, occupies the extreme point of a promontory which projects considerably from the main land, and divides the bay into two basin-like recesses. This promontory, which is 150 feet above the level of the sea, and 200 feet across, is so nearly perpendicular, and so nearly alike in all its faces, that it has the appearance of an artificial structure raised for the defence of the harbour. It is formed of pure carbonate of lime, and looking at it merely as a dry mass of chalk, washed on three sides by the sea, we should imagine it to be one of the healthiest situations in the West Indies; yet, strange to say, the inhabitants at its base, and living on the banks of a sluggish river, covered with mangrove, are healthy, while the troops quartered on the rock were so rapidly destroyed by fever that for some years past it has not been garrisoned. In attempting to assign the law which may explain these varying and often apparently opposite phenomena, there is no hypothesis so satisfactory as that which supposes the diffusion of the paludal poison to follow the same laws as those which govern the vapour or dew, by which it is held either in a state of solution or suspension, and which, it is well known, is variously attracted and repelled by various soils, and the vegetable productions which cover them.

*Predisposing Causes.*—The paludal poison spares no *age*; for the infant at the breast, the adult, and the decrepit with age, are alike seen to shake with ague, or to suffer from some severe form of the disease. The adult, however, from his greater exposure to the cause, suffers the most. It has been supposed that our liability to the action of this poison decreases with increasing years; but the veteran soldier is found to suffer in a two-fold degree over the recruit. It is well known that the life of a woman is twice as good as that of a man, in the West Indies; but when the wives of the common soldiers have been equally exposed with their husbands, they have suffered in an equal proportion.

It appears that *race* greatly affects the liability to this class of disease. The white troops in the West Indies suffer a mortality of 36·9 per 1000, while the black troops only lose at the rate of 4·6 per 1000 from the same cause. It is certain that in every country the natives suffer much less than strangers; the sepoys, for instance, suffer as one in four and a-half, Europeans as one in three. Our invasions of Holland, Spain, of the Birman and Chinese empires, have been most disastrous to the troops; not, however, from losses in battle, so much as from the devastations of paludal disease, while the natives of those countries have not suffered in any unusual degree. The expedition of the French to Africa has also been attended with a similarly great fatality.

The different ranks of life have also a different liability; thus, the soldier is twice as liable to paludal fever as his officer. In every country, also, the poor suffer more than the rich; and again, the largest proportionate loss has occurred in the most densely populated districts. It has been supposed that habits of rigid temperance are not greatly protective from this disease. When, however, intemperance leads to exposure to the night air, it is most pernicious; and our armies, when on actual service, have on all occasions been more than decimated in a very few days from these conjoined causes. The most healthy period of the day is from three to six in the afternoon, after the greatest heat of the day is past, and before the dew falls. The most unhealthy is from sun-set to sun-rise. The most unhealthy season of the year is when the greatest degree of heat is combined with the greatest degree of moisture, or, in the northern hemisphere, between July and October. It is then we should take care that the sickening damp, the cold autumnal fog, "hang not relaxing on the springs of life."

*Susceptibility not exhausted.*—It has been supposed that a long residence in a paludal country destroys all susceptibility to the action of the paludal poison; but the returns published by the War Office and Army Medical Department painfully show a contrary result in the West Indies. Thus, while the annual mortality among the troops resident one year in Jamaica was 77 per 1000, mean strength; in those resident two years it was 87 per 1000; while of those still longer resident, it was no less than 93 per 1000.

It has also been imagined by many writers that persons who have suffered from one attack of paludal fever have an immunity from a second attack; Sir James Mac Grigor, however, states, "That in making calculations of efficient force, this description of men could not be relied on for operations long continued in the field," for "we found that in those who were convalescent or lately recovered from ague, the causes next prone to re-produce the disease were exposure to a shower of rain, or wetting the feet, full exposure to the direct rays of the sun, or to cold, with intemperance, irregularity, or great fatigue." There are many instances, also, of the same party being repeatedly attacked with the West Indian fever.

*Co-exists.*—This law has not been sufficiently studied; but small-pox and intermittent fever, scabies and intermittent fever, have often been seen conjoined, and there can be no doubt of the simultaneous existence of the paludal with many other morbid poisons.

*Modes of Absorption.*—It is apprehended the paludal miasmata are absorbed in all cases by the mucous mem-

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branes either of the lungs or alimentary canal; and being absorbed, that they mingle with the blood. Dr. Russell, at least, gives a case of a pregnant woman, labouring under ague, shaking at one hour while her fœtus shook at another, and that they were both cured by bark.

*Period of Latency.*—The period of time after exposure to the cause that the poison may lie latent, varies according to its intensity and the state of the recipient. In the West Indies men have been brought to the hospital ill of fever the night after landing; but the more usual period in tropical countries is three, four, or five days, to a fortnight. In more temperate climates the period of latency is usually much longer. The minimum of time may, perhaps, be as short as in the West Indies; but more commonly the poison lies latent for many weeks, and sometimes for many months. On the return of our troops from Walcheren great care was taken to quarter them in situations remote from all known sources of marsh miasmata; yet fresh cases continued to occur as late as five, six, eight, nine, and even ten months afterwards. It is probable, therefore, that cases of ague received into our hospitals in winter and early in the spring must have been contracted in the preceding summer or autumn.

*Pathology.*—The theory of this disease is, that the paludal poison is absorbed and infects the blood, and after a period of latency, more or less long, produces, according to the dose, functional disorders of the great nervous centres, terminating in the phenomena either of intermitting, remitting, or else that peculiar form of remittent termed yellow fever. These fevers may exist without any alteration of structure being set up, and the patient often dies from the severest forms, with hardly a trace of disease being discoverable. In the milder forms of these fevers, however, when the disease is prolonged, the poison acts upon and disorganizes a greater number of organs and tissues than almost any other poison, as the liver, spleen, lungs, heart, brain, and the serous and mucous membranes of the body generally. The specific actions, then, of the poison, within certain limits, may be said to be in the inverse ratio of intensity. The affections of the liver and spleen also very greatly, according to the country; for in some parts of India the spleen is the organ chiefly affected, while in other districts it is the liver; the nature of the country, perhaps of the soil, impressing evidently some peculiar character on the poison.

The patients labouring under intermittent fever, or a minimum dose of the poison, in and about London, generally recover under medical treatment without any manifest derangement either of structure or of function of any organ or tissue. When, however, the disease is neglected, the poison may fall on the liver, and occasion merely disordered function of that organ, as jaundice; or it may produce inflammation, of which jaundice may or may not be a symptom; and this inflammation may be acute or chronic, diffuse or suppurative. If a liver, previously healthy, becomes the seat of diffuse inflammation, it is of the deepest hepatic tint, and loaded with blood; and we find it also often greatly hypertrophied, filling the abdominal and pelvic cavities, and according, perhaps, as the inflammation is acute or chronic, either greatly indurated or else so softened as to be easily broken down. In a few instances this inflammation may terminate in abscess, and generally of the usual phlegmonous character. On the contrary, if the liver be previously diseased, its colour, even when the seat of abscess, or otherwise most acutely inflamed, may be of the palest yellow, and its texture sometimes so soft and broken down that the blood-vessels may be dissected out with the fingers, or else so indurated as to form a muscular shapeless mass, of varying magnitude. When abscess forms it may rupture into the duodenum, or into the cavity of the abdomen, or it may point externally.

The paludal poison also often produces structural alteration of the spleen. In these cases that organ has been found sometimes so enlarged as to weigh 10 to 30 lbs., greatly exceeding the liver in size, while in other cases it is sometimes even less than natural. In consistency, also, it varies from a state of almost fluidity, a mere bag of blood, to a hardened mass, with a distinct indurated edge. It is also sometimes the seat of abscess.

When the poison falls on the peritoneum its functions may be alone deranged, so as to produce dropsy. Every form of peritoneal inflammation, however, may precede or accompany the ascites,—as the diffuse, the serous, the adhesive, or the purulent; and these forms may be either acute or chronic, but more commonly they are acute.

These are the most usual alterations of function and of structure in the mild paludal fevers seen in and about London in the present day; and in estimating the relative frequency of these secondary affections, ascites is the most common, then jaundice; while peritonitis, hepatitis, and splenitis are less frequent, and occur, perhaps, in nearly equal proportions.

The pathological phenomena which a medium dose of the poison produces, or that which gives rise to severe intermittent and mild remittent fever, are much more severe, and extend over a greater number of organs. Sir Gilbert Blane, in his observations on the Walcheren fever, remarks, that the structural derangements were more frequent, swelling of the liver and spleen than taking place in a very few weeks; which in England seldom occur, except under a long continuance of the disease, or after frequent relapses. The morbid anatomy, however, also extends to the mucous membrane of the stomach, which in a few instances was inflamed and ulcerated, and the ulcers had generally a sharp perpendicular edge, as if made with a punch. In such cases also as died dysenteric the large intestines, and more particularly the sigmoid flexure and the rectum, were always much contracted, thickened, inflamed, and ulcerated; the ulcers being often so numerous and so confluent that the whole inner surface of the gut appeared in a state of granulation.

The peritoneum was also very generally inflamed, especially that portion which covers the different organs, caused perhaps by extension of the morbid irritability of those parts, and from this circumstance the different viscera often adhered to each other and to the walls of the abdomen; and sometimes it also happened that an encysted abscess formed between the adherent surfaces. In other cases the intestines were often seen floating in serum or pus, or else were glued together. In dropsical and dysenteric cases the peritoneum was unusually thickened, while abscess occasionally formed in the folds of the mesentery.

The serous membranes of the chest were also frequently the seat of disease. Sometimes a dropsical effusion filled the cavity, in other cases the pleura pulmonalis was almost universally adherent to the pleura costalis, while in others the whole surface of the membrane was covered with recently effused coagulable lymph. In some cases the anasarca was general, but



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the more remarkable effusion of serum was around the epiglottis, when it formed a large tumor, sometimes as big as a turkey's egg, completely closing up the rima glottidis and suffocating the patient. The epiglottis also was in some cases found ulcerated and thickened. Bronchitis and laryngitis were not unfrequent, while the substance of the lung was sometimes the seat of severe inflammation, terminating either in the red or grey hepatization, or with effusion of serum.

The heart itself did not always escape the inroads of this destructive poison, for the pericardium was frequently found inflamed and covered with lymph, or else the seat of serous effusion. It was even seen ulcerated, and its adipose membrane œdematous.

The membranes of the brain were also often the seat of much inflammation, lymph or serum being often effused between them, while much water was occasionally found in the ventricles. The substance of the brain also, especially in dropsical cases, was so soft as hardly to bear the knife. Such are the destructive effects of a medium dose of paludal poison.

The maximum dose of the paludal poison producing the severer forms of remittent and of yellow fever does not occasion the same amount of disorganization. In this respect the paludal poison follows the great law of poisons generally, or, the dose being in excess, the patient falls before sufficient time has elapsed for the poison to set up its specific actions. "In cases of the Wynaad fever," says Mr. Walsh, "though black vomit and yellowness of the eyes were frequent, and they terminated fatally in four or five days, there was scarcely any vestige of local injury or of disorganization." Mr. Amiel also affirms, that the rapid progress and short duration of the Gibraltar fever left no time for visceral obstructions to be formed.

As a general principle, in the West Indies, in Africa, and indeed in all countries in which remittent fever is of the highest degree of intensity, the traces of diseased structure are always trifling, and limited to the stomach, the brain, the liver, or the spleen. When the stomach is affected, the mucous membrane of the pyloric orifice is for the most part inflamed, easily detached, and sometimes ulcerated. The contents of the stomach also are either a viscid mucus, or that black melanic matter which is sometimes thrown up, or else pure blood. In 7-10ths of those examined at Barcelona, in 1821, the stomach contained melanic matter, like soot mixed with water, or coffee-grounds, while in 1-8th it contained pure blood. The duodenum and small intestines, and not unfrequently the gall-bladder, were also inflamed. Dr. Barry and Mr. Rufz speak of having observed Brunner's glands to be enlarged, but never Peyer's. The small intestines also are filled with the same matters as the stomach, but more viscid and thicker, and more resembling tar; and in the large intestines these matters were often mixed with clotted blood. The liver and spleen have usually been found healthy. Louis states, that in the epidemic at Gibraltar he found the liver of a pale yellow colour, a circumstance he considers to be the great pathognomic sign of the disease. It is probable, however, that this generalization is hasty, for it was not observed by our own officers, and has since been found wanting in the epidemic at Martinique. The substance of the brain is in general healthy, and sometimes a little softened, while the membranes are only occasionally inflamed with the usual effusion of serum.

*Symptoms.*—The paludal poison, according to the dose, or else according to the susceptibility of the party, produces two distinct varieties of fever, or the intermittent and remittent fever. The former has many varieties, denoted by the different periodic intervals which elapse between each paroxysm, while the varieties of the latter are denoted by the greater length of the febrile paroxysm, and by the greater gravity of the disease altogether. The varieties of intermittent fever are,—

Febris intermittens quotidiana,
Febris intermittens tertiana,
Febris intermittens quartana.

The varieties of remittent fever are,—

Febris remittens mitior,
Febris remittens gravior,
Febris remittens gravior cum ictero.

The relative frequency of these different types varies greatly in different countries, as also their aggregate amount. In the Windward and Leeward command the admissions for intermittent fever form about two-fifths of the total number admitted labouring under fever. But it does not prevail equally in all the settlements belonging to this command, but is principally confined to the low marshy settlements of Demerara and Berbice, where it has been a great source of inefficiency, particularly since 1830; the number attacked in the course of the year having been often equal to the whole force of the colony. Intermittents also are very common in Trinidad, owing to the vicinity of the barracks to the marshes; but in the other islands they are comparatively rare, and in some almost unknown. In Jamaica intermittents form about one-seventh of the whole number, while at Bona, in Africa, they are as 3 to 2, and again in the Ionian Islands they are about 1 in $3\frac{1}{2}$ nearly.

The minimum dose of the paludal poison gives rise to the simplest and least dangerous form of the disease, or to *intermittent fever*, of which the varieties are distinguished from each other by the interval of time which elapses between each paroxysm. For instance, when the paroxysm returns every 24 hours it is termed a *quotidian*, when every 48 hours a *tertian*, and when every 72 hours a *quartan*; and these primary types have been extended by early writers to every period comprised within a mensual or bimensual period.

Of these primary types it has been supposed that in this country the tertian is by far the most common, then the quartan, and lastly the quotidian. But this law is by no means general, for M. Maillot treated 2354 cases of intermittent fever occurring in the French army in occupation of a portion of the northern shores of Africa, and he found of that number 1582 were quotidian, 730 tertian, and 26 quartan. In the Peninsular war the quotidian was likewise the prevailing type, and at one time they were in the proportion of 16 to 1 of any other type. In the West Indies the tertian and the quartan are only about one-twelfth of the whole number of intermittents treated, the rest being quotidians.

Most authors who have written on intermittent fever have stated that the accession of the quotidian paroxysm occurs early in the morning, that of the tertian about noon, and that of the quartan in the afternoon, between 3 and 5 o'clock. But to this law there are many exceptions; for, according to Maillot, of 1582 quotidians 1089

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occurred from midnight to midday, and 493 from midday to midnight; of 730 tertians 550 occurred from midnight to midday, and 180 from midday to midnight; out of 26 quartans also 13 were seized from midday to midnight, and 13 from midnight to midday. As the most general conclusion, the paroxysm returned in a great majority of the quotidian cases from 10 to 12 o'clock, and in the tertian from 9 to 12 o'clock.

The febrile paroxysm, or fit of intermittent fever, has three stages: a cold stage, a hot stage, and a sweating stage. These three stages are not necessarily of an equal duration, but vary greatly in different cases. The duration of the cold stage is from a few minutes to five or six hours, and in general, if the disease be severe, the shorter the cold stage the longer the hot stage. The hot stage may last from half an hour to any period less than 24 hours. The sweating stage is generally shorter than either of the former, and sometimes does not exist at all. The rule, however, is, that the quotidian has the shortest cold stage and the longest hot stage; the tertian a longer cold stage and a shorter hot stage than the quotidian; while the quartan has the longest cold stage and the shortest hot stage of all the varieties.

The disease may be sudden in its attack, and without previous illness, but more commonly it is preceded by general indisposition, headache, weariness, pain in the limbs, thirst, loss of appetite, white tongue and frequent pulse, high coloured urine and dark coloured discharge from the bowels. These prodromes are accompanied with well-marked exacerbations and remissions of fever, displaying a periodic tendency. After this feverish state has lasted from four days to a fortnight, the patient is seized with severe rigor, and the ague is manifested. The phenomena of a paroxysm are the following:—

The paroxysm, like the disease, may be of sudden invasion, and the patient in good health up to the time of attack; or it may be preceded by languor, debility, frequent yawnings, and great unwillingness to make the least exertion. In whichever way the cold stage begins the patient experiences first a sensation of coldness of the extremities, then of the back, and lastly of the whole body; at the same time the nails turn blue, the features shrink and become pale and sharp, and if the case be severe the whole body shrivels up, turns purple, and is "goose-skinned." The coldness increasing, the motor nerves of the fifth pair are affected, and the teeth begin to chatter; and this tremor extends to every muscle, till the whole body shakes with rigor. Cough, dyspnœa, and oppression of the præcordia now occur, with a painful sensation round the temples and down the back. The patient also often suffers from nausea and vomiting, and the latter symptom is speedily followed by the hot stage. When the cold stage has lasted a period varying perhaps from half an hour to two hours and a half, a re-action takes place, accompanied by partial warmth, or flushings. These extend, and at length the whole body acquires a heat greater than natural, or from 105° to 107°. As the heat returns so also does the colour; and the body, especially the face, becomes now preternaturally swollen and red. The hot stage being now formed, the heart and arteries beat with unusual violence, and headache, with a frequent full pulse, and all the distressing symptoms of continued fever, are present. "The mean duration of this stage is from three to eight hours. At its close a gentle moisture breaks out, first on the forehead, and thence extends till the patient lies in a general sweat, sometimes so profuse as to soak the bed and linen as completely as if they had been dipped in water. After the sweat has continued to flow for some time the fever gradually abates, a state of apyrexia ensues, and the paroxysm is terminated, and, a sense of exhaustion excepted, the patient feels restored to health. Sometimes, however, he continues pale, debilitated, and incapable of all exertion, till, on the recurrence of the paroxysm, the symptoms just described are repeated.

Upon the approach of the attack the pulse is slow and feeble, but as the sense of coldness increases it becomes small, rapid, and irregular. When the hot stage forms it becomes full and strong, and on the sweat breaking out it again becomes soft, less rapid, and at length natural. In the course of the paroxysm there is a considerable change in the urine, which, during the cold stage, is abundant, colourless, and without sediment. In the hot stage it is high coloured, but still void of sediment; but as soon as the sweat begins to flow a sediment, commonly lateritious, is deposited, and this deposition continues for some time after the paroxysm is terminated. The tongue, in mild forms of the disease, is clean in the cold stage, white in the hot stage, and again cleans after the sweat has flowed. In severe cases the tongue is white during all the stages, and also during the apyrexia, while in the worst cases the tongue is brown in all the stages. Excepting some unusual instances, attended throughout with diarrhœa, the patient seldom passes a stool till towards the close of the paroxysm, when it is generally a loose one. It frequently also happens during the cold stage that tumors subside, or ulcers dry up, but the tumor generally reappears, and the ulcers discharge as soon as the sweating stage is formed.

The paroxysm of intermittent fever, of whatever description, is conventionally considered to terminate in 24 hours; for, if prolonged beyond that time, it is termed remittent fever. The duration, however, varies in different types. Dr. Brown conceives the mean length of a quotidian to be 16 hours, that of a tertian 10 hours, and that of a quartan 6 hours. In London, however, this calculation is greatly in excess: for, in the majority of cases, the paroxysm, whatever be the type of the fever, seldom exceeds two to six hours, and consequently the mean is hardly more than four hours.

It is seldom that intermittent fever, of whatever type, consists of a single paroxysm, for usually it recurs many times, so that the whole duration of the disease, if left to nature, would be extremely long. Horace speaks of its lasting five months, while Sydenham extends this period to six months, stating, if bleeding has been used it often lasts for 12 months. Under the present improved treatment in London the disease is generally terminated after a very few paroxysms, perhaps three or four, the patient being now removed to an atmosphere free from the paludal poison. If the disease be neglected, the fever becomes complicated with dropsy, peritonitis, hepatitis, splenitis, inflammation of the lungs, or with dysentery, then the symptoms peculiar to those disorders will be added.

*The Symptoms of Remittent and Yellow Fever.*—A higher degree of the paludal poison, or a medium and a maximum dose, produces remittent fever, and its more intense form, yellow fever, for the latter disease differs in no respect from the former, except in the jaundice, which accompanies it, and in the remissions being less

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complete. There are so many grades of intensity in remittent fever, varying as it does from a severe intermittent to yellow fever, and so many different modifications impressed on it from the great variety of country by which the poison is generated, that it is extremely difficult to generalize the phenomena.

The severer forms of remittent fever may be preceded by languor, restlessness, or chilliness, symptoms which usher in a short cold stage; but in other cases the attack is sudden, and the patient, for instance, immediately after a hearty dinner may be seized most unexpectedly with faintness, vertigo, confusion of thought, and these almost without a rigor; a hot stage, usually of much greater intensity than that which accompanies the worst forms of intermittent fever, follows.

The hot stage is usually marked by much cerebral affection: as severe headache, a painfully acute state of every sense, an injected state of the conjunctiva, and great action of the carotid arteries. These symptoms are frequently accompanied by delirium, sometimes of a violent character, while in other cases the patient is oppressed with great drowsiness, lethargy, or coma. The stomach also often is the seat of great pain and uneasiness, followed by vomiting, and the matters vomited are either colourless or bilious, or else blood. The duration of this paroxysm varies considerably, and when the disease is mild it may terminate in six or seven hours, but if severe it may last 15, 24, 36, or even 48 hours; and Dr. John Hunter once saw a case in which there was no remission for 72 hours. The fever, however, at length remits, sometimes with sweating, but at other times without any sensible increase of perspiration.

The duration of the remission which follows is as various as that of the hot stage. Sometimes it does not last longer than two or three hours, more commonly it extends to 10, 15, 30, or even 36 hours. The fever then returns, and in some cases assumes a quotidian type, and has an exacerbation every day, and perhaps nearly at the same time, yet more frequently there is no regularity in the times either of its accession or remission.

The second paroxysm is always more severe than the first, if the progress of the fever has not been checked during the remission, and usually neither any cold stage, rigor, or even chilliness precedes it. On the other hand, all the febrile symptoms run much higher, the skin is hotter, the pulse more frequent, the headache greater, the senses more confused, and the delirium or coma, when that exists, more violent in degree and more sudden in its accession; and these symptoms sometimes persevere with or without the black vomit, till they terminate perhaps in convulsions, and at length in death.

This severe remittent fever is sometimes accompanied by a symptom which has given a name to this disease as though it were a distinct species, or a yellowness first of the eyes and then of the skin, and hence the term "yellow fever." The yellow fever, however, is simply a remittent fever, with the addition of jaundice, a variety remarkable only for its great severity, and for the sudden aggravation of all the symptoms. The jaundice may occur in the first paroxysm, accompanied by a sudden and almost total loss of strength, by stupor, subsultus tendinum, pain and irritability of the stomach by incessant retching, and that retching the black vomit, and so violent or profuse that the patient sometimes dies in twelve hours. More frequently, however, the jaundice does not appear till the second or third paroxysm, and the patient then sinks with all the bodily and mental affections incident to the last stage of typhus. Occasionally, however, the course is different.

Dr. Wilson has remarked, that the term insidious has often been applied to the West India fever, and with great propriety: for he states, that while the poison is frequently sapping the powers of life there is often little to inform us of the mischief that is going on within, so that the symptoms frequently do not prepare us for the fatal issue. "In the midst of our security," he adds, "and when we are imagining all is going on well, we are shocked by the sudden eruption of the black vomit, or the accession of profound coma, rapidly producing death." The insidious nature of the severe forms of paludal disease was remarked also by Dr. Barry at Sierra Leone. "The state of the patient's mind was also most peculiar, for the poor sufferer appeared entirely unconscious of his hopeless state, and generally expressed himself as being much better, until, the vital heat receding from the surface, dissolution took place, sometimes preceded by violent straining of the eyeballs and incoherent expressions, or else by some convulsive motions. At Gibraltar the patients sometimes died without taking to their beds, or "on foot," as it was termed. The following case is given by Louis:—Dr. Matthias, who died at Gibraltar after an illness of four or five days, experienced no other symptoms than severe pains in the calves of the legs and a suppression of urine. He had no nausea, and did not vomit, and his mind was clear during the whole course of the disease. He noticed, however, the suppression of urine, dictated three or four letters to a friend, begged him to write rapidly the last, that he might sign it, then devoted a short time to an affectionate intercourse with this friend, and soon after, becoming speechless, he thanked him by a sign, and in a quarter of an hour was dead.

In the interval of the paroxysm the patient in some few cases still retains some power, but more generally the prostration is great. Dr. Arnold says, that there is no disease in which the muscular power is so much impaired from the commencement to the termination, particularly if the invasion be brought on by syncope. Dr. Davy also says, "When I reflect on the severe cases, no other disease occurs to me, excepting spasmodis cholera, which gives such an idea of the energies of the constitution being overpowered as if by a subtle active poison."

This disease is in a few instances fatal within 24 hours, often on the third or fourth day, and in almost every case the patient, if he does die, dies before the seventh, or at most the ninth day.

*Diagnosis.*—If one paroxysm constituted an ague, there are many diseases which might be said to simulate intermittent fever, as erysipelas, pneumonia, and almost every acute affection; but the absence of a second paroxysm, and the formation of an entirely different disease, readily distinguish them. The last stage of the mild form of remittent fever cannot always be distinguished from typhus.

*Prognosis.*—No patient ought to die in this country from simple intermittent fever, provided he can be removed from the marshy district.

The mortality from intermittent, remittent, and yellow fever, according to the reports of the sickness and mortality occurring among the troops in the West Indies, the Mediterranean, and in North America, and presented to both Houses of Parliament, is as follows:—

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Elementary Principles of Medicine.

| Deaths from | Windward & Leeward Command. | Jamaica Command. | Gibraltar. | Malta. | Ionian Islands. | Upper Canada. | Lower Canada. |
|---|---|---|---|---|---|---|---|
| Intermittent fever . | 1 in 169 | 1 in 163 | 1 in 60 | 1 in 311 | 1 in 230 | 1 in 1143 | 1 in 535 |
| Remittent fever . . | 1 in 9 | 1 in 8 | 1 in 11 | 1 in 24 | 1 in 22 | 1 in 11 | 1 in 5 |
| Yellow fever . . | 1 in 2¼ | 1 in 1½ | 1 in 1⅜ | .. | .. | .. | .. |

When troops are on actual service in tropical countries the mortality from severe remittent and yellow fever is often enormous. In the attack on Carthagena the troops remained on shore but 10 days, yet on re-embarking the sick were to the healthy as two to five, and ultimately one-fourth of the whole number died. In the late expedition to the Birman Empire, within three months of taking possession of Rangoon, more than 3000 men had died, or more than one-half the entire force.

*Treatment.*—There would have been no end to the miseries inflicted on mankind by intermittent fever had not the very antidote nature seems to have provided against the mild form of paludal disease been at length discovered. The plant cinchona, as well as its sanatory properties, is said to have been known to the natives of Peru long before the discovery of America, but to have been kept secret by them out of hatred to the Spaniards. The Jesuits, however, became acquainted with its specific virtues, and employed it in 1638 in the cure of Count El Cinchon, a Spanish peer and viceroy of Lima. The remedy was successful, and it became celebrated throughout Europe. It was first exhibited in powder in two-drachm doses twice a day, and was subsequently given as a decoction, as an infusion, as a tincture, and also as a wine, the bark being steeped in port wine. Of these various modes it was, however, determined that in severe disease the powder, when the stomach is not too irritable to bear it, is the most efficient, and the dose of the pulvis cinchonæ has been fixed by general usage at a drachm for an adult; and this dose given every four or six hours has been found, when persevered in for three or four weeks, or longer, to cure the great majority of intermittents in and about London. Occasionally this dose has been found inefficient, and it became necessary either to increase the quantity or to augment its efficiency by additional stimulus. Drs. Fordyce and Huck increased the quantity so far as to give half an ounce, and even an ounce, for a dose, and a few cases were cured by this means; but the stomach so often rejected this crude mass, and the incessant vomiting which often followed so constantly retarded the convalescence of the great majority thus treated that this excess of dose has in general been abandoned. It was then found that an additional stimulus was generally more efficient than an increased quantity of cinchona, and that a scruple of Cayenne pepper added to each drachm of bark frequently succeeded in curing an ague, when bark alone had failed. Sometimes, however, even bark combined with Cayenne pepper (piper Indicum) was inefficient, and in these obstinate cases opium was found to be an admirable adjuvant, and the triple compound of pulveris cinchonæ ʒj. piperis indici ℈j. c. opii gr. j. 4tis horis has in general been found an adequate remedy for the most intractable intermittents met with in London.

The occasional failure of crude bark, notwithstanding the use of many auxiliary remedies, rendered some further additional power a great desideratum, and we owe to Pelletier and Caventou the discovery and isolation of *quina*, one of the alkaloid principles of cinchona, and which endless experiment has shown to be the real antidote to the paludal poison, when of such intensity as merely to produce intermittent fever; and the introduction of this substance into medicine has rendered all other modes of treatment, when the disease is not as yet complicated with organic lesion, unnecessary, at least in London. Quina sits easily on the stomach, even in large doses, and about five grains are esteemed equivalent to one drachm of crude powdered bark. There are two modes in which it may be exhibited, or in small and repeated doses at short intervals, or else in one large dose once in 24 hours. The latter method, however, seems the most preferable, for on a comparison of many cases treated by one, two, to five grain doses given every second, fourth, or sixth hour, with others treated with ten grains in one dose every night, it has resulted that one large dose of quina has effected the cure of the patient in less time than double the quantity given in small and frequent doses; thus not only demonstrating that the large dose is more beneficial to the patient and more economical of quina, but also that the cure must be effected rather by the impression made on the nerves of the stomach, than by the quantity absorbed. The disulphate of quina is the preparation generally used, and is probably the best; and 10 grains of this substance given every night often stops the fever at once, more commonly after three or four paroxysms, and always in the course of a very few days. It is unimportant whether this substance be given in pills, out of camphor mixture, or in solution by means of dilute sulphuric acid, in the proportion of one drop to each grain of the salt. It is necessary to add, however, that whether bark or quina be exhibited, or whether the dose be large or small, the patient should continue its use for a fortnight or three weeks after the last paroxysm, in order to guard against relapse, for the diseased actions appear to be suspended for some time before they are cured. It is desirable, perhaps essential, also, that the patient should be removed from every source of the paludal poison. The medicine should be given during the state of apyrexia.

When intermittent fever becomes complicated with secondary affections of the paludal poison, so that inflammation of the peritoneum, of the pleura, or else dropsy of those membranes, ensues, the treatment by quina must be either modified or abandoned. If inflammation be the result, local or general bleeding must be had recourse to, yet not to any extent, for as the inflammation depends on the action of a poison, the utmost we can hope to effect by that operation is to moderate the symptoms. This limited bleeding is to be followed by the exhibition of mercury, so as to affect the mouth. Five grains of calomel, given once or twice in the 24 hours, is generally sufficient, but the quantity and frequency of the exhibitions must be proportioned to the severity of the attack, and there are very few cases which do not yield as soon as the gums are

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affected. The beneficial effects of calomel are indeed so striking, that a much greater latitude may be allowed than in similar cases of simple phlegmasiæ, with respect to refraining from bleeding.

If the secondary action of the poison produces merely disordered function of the serous membranes, ending in dropsy of the abdomen or chest, bleeding is unnecessary or injurious, while mercury is still the most useful, and indeed essential agent; for few cases of paludal dropsy resist, in London, the action of five grains of calomel, repeated every night till the mouth is affected; and this medicine is much to be preferred in these cases to squills, elaterium, digitalis, or any of the large class of neutral salts, which are found so useful in the simple forms of dropsy. It is necessary, should intermittent fever and dropsy co-exist, that quina be exhibited in combination with the calomel; if otherwise, it is unnecessary.

When the paludal poison so deranges the functions of the liver as to occasion jaundice, mercury is still the only beneficial remedy; nor are large quantities of it necessary, for five grains of the pilula hydrarg. or two grains of calomel every night, are in general all that is necessary to remove the complaint. In this case, should the febrile paroxysm continue, the one large dose of the disulphate of quina every night should be still exhibited.

It is unusual to meet in London, in the present day, with intermittent fever accompanied by *acute* hepatitis or splenitis, so that we have few opportunities of determining the most satisfactory modes of treating them; but it is apprehended that bleeding and mercury, or mercury and the disulphate of quina, will, according as the fever is or is not present, be found the most efficient remedies, at least for hepatitis, whether acute or chronic. We possess, however, no satisfactory mode of treating acute splenitis, and when that disease becomes chronic, the case is still more hazardous. It seems determined that mercury and bleeding in these cases are both decidedly injurious, so much so that the Indian practitioners employ a spleen powder, composed chiefly of equal parts of sulphate of iron, of cream of tartar, and of *jalap*. In this country that compound has not supported the character it has acquired in India, and some few apparently hopeless cases have been successfully treated by the iodide of potassium, gr. viij. ter die. Dr. Williams, of St. Thomas's Hospital, has published some few cases in which the bromide of potash, in doses of five grains, out of camphor mixture, appeared to have considerable influence over these large and indurated spleens. After the ague has been cured there often remains a troublesome and protracted nervous affection of one side of the head, bounded by the sagittal suture, though not unfrequently occupying the occipital portion. A continuance of quina is more useful in removing this affection than bleeding, cantharides, or blisters.

*Cure of Remittent Fever.*—Quina is unquestionably a most efficacious remedy, indeed a specific, in the cure of simple intermittent fever, and bleeding and mercury in removing most of its consequences. It is to be regretted, however, that these remedies, either separately or combined, are much less efficacious in the cure of the severe remittent forms of the disease; yet, as they are the most powerful agents we possess, it is desirable to ascertain their respective values.

The ancients generally bled, but most unsuccessfully, in intermittent fever; and Sydenham, Morton, and Cleghorn immediately abandoned that operation on the introduction of bark. Bleeding, therefore, having failed in the mild forms of the disease, little could be expected from it in the more severe ones; and this operation, when practised on a large scale, appears to have effected little good. "In the Walcheren expedition," says one of the medical officers, "I bled patients and saw others bleed them, but it was only to see them die." In the Rangoon expedition bleeding was the favourite remedy, yet in less than three months one-half of the British force were laid in their graves. Mr. Ameil says, that at Gibraltar bleeding, both in large and small quantities, was tried, and under the most marked indications, but "I experienced no favourable results." In the treatment of the French troops employed in Africa, M. Maillot says his patients became so frequently delirious or comatose, and in this state were carried off in a few hours, that he entirely abandoned the practice. Dr. Davy also considers bleeding, in the remittent incident to the Ionian Islands, to be decidedly injurious. In the East Indies, in the West Indies, and in Africa, and indeed to whatever quarter we turn, we find the large majority of practitioners adverse to the practice of bleeding. Many speak of it as not producing much mischief, if moderate in quantity and early in its application; while only a few advocate its extensive use. It may be affirmed, then, as a general principle, that bleeding to any amount is either inefficient or injurious in every form of paludal fever. Some depletion, however, either by the lancet, cupping, or leeches, may be necessary to save a threatened organ; but bleeding, carried to the extent which might be borne in the simple phlegmasiæ, seems quite unwarranted, not only by the laws of poisons, but by the experience of the profession generally.

The property which mercury possesses of controlling many of the secondary affections in intermittent, has caused it to be extensively employed in the cure of the remittent and yellow fevers, but with extremely questionable success. In the Walcheren expedition it was largely used and fairly tried, yet it was admitted to have most egregiously disappointed the hopes of the medical officers. It appears, also, to have been used with an equal or greater profusion in the Rangoon expedition, and with what lamentable result has been already mentioned. In the West Indies Dr. Chisholm has given as much as 6000 grains of this metal, externally and internally, in a single case of yellow fever; and in America it has been almost equally largely employed. It has appeared to result, that mild cases have recovered under this treatment, as they would, perhaps, have done under any other; but in severe cases it has, for the most part, been unsuccessful, and in many instances palpably injurious, and is now more commonly used as a purgative than as an antidote.

Bleeding and mercury, either separately or conjointly, having been proved to be inefficient, crude bark was very generally used between the tropics in the cure of remittent fever, sometimes throughout the disease, and at other times only during the intervals; and it has been asserted that more recoveries took place under this treatment than under any other; still, however, the great irritability of the stomach often caused it to be rejected in every stage, and the life or death of the patient often appeared to turn on the quantity of wine or other nourishment that could be got down during the remission. The introduction of quina in the cure of this affection has had many prejudices and difficulties to

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contend with, from the previous frequent failure of bark, but it promises to produce a new epoch in the treatment of the remittent fever. In the East Indies it has been found to possess the means of controlling that disease to an extent hitherto deemed impossible. In the West Indies, also, it is now generally used, and its great powers admitted; and on the coast of Africa, in the treatment of the French troops, M. Maillot conceives he has reduced the mortality from one in four and a half to about one in twenty-two, by the use of this remedy. The dose, however, given by this gentleman is enormous, for in bad cases he gives from one to two scruples by the mouth, and 60 grains as an enema; and in this manner he has in several instances given as much as 148 grains in the 24 hours. These large doses he states to have been generally successful, and never produced any engorgement of the viscera, dropsy, diarrhœa, or other unpleasant symptoms.

It is impossible, after such evidence, to doubt the great value of quina in the cure of remittent fever. The battle, however, still rages between those who would still treat this disease symptomatically, or by moderate bleeding, effervescing draughts, purgatives, and also supporting the patient in the remission by wine, strong broths, and those who prefer the specific remedy. The increasing intelligence, however, of the medical profession, will in a few years determine the circumstances, and the time, and the dose in which this remedy should be exhibited; and if we make a due allowance for that severe form of disease which renders all remedies powerless, we shall eventually see it occupy a high place in the cure of remittent fever.

*Dietetic Treatment.*—There is something extremely inimical in an animal diet in every case of disease from a morbid poison; and consequently, though broths may be useful and necessary during the intermission or remission, the diet of the patient from the commencement till the termination of the disease, whether remittent or intermittent, should be strictly antiphlogistical, and limited to a milk diet, slops, vegetables, and jellies, and, according to the discretion of the practitioner, to some wine.

*Preventative Treatment.*—The question of prevention necessarily involves the doctrine of the contagious or non-contagious nature of paludal fever generally. The milder forms of paludal fever are certainly not contagious; for the London Hospitals often contain a considerable number of cases of intermittent fever; yet in no well-authenticated instance has that disease been known to spread to any patient in the ward, or to any medical or other attendant. On the return of our troops from Walcheren, labouring under every grade of remittent and intermittent fever, not one orderly, nurse, or medical attendant suffered from either of these fevers, who had not been previously exposed to the action of the paludal poison,—the contrary, it will be remembered, of what happened when they returned suffering under typhus from Spain.

In the West Indies it is the common practice to send convalescents from the towns to the mountains; but no instance is known of yellow fever spreading in those higher districts. In the West Indies, also, it was formerly the custom to place the fever as well as the other patients in contiguous beds, and even in tier over tier; yet no instance has been observed of the disease spreading. In the years 1796-1797, when the army under Sir Ralph Abercrombie suffered dreadfully in the West Indies from fever, the Inspector-General reported to the Army Medical Board the opinions of the medical officers on the staff on the subject of contagion, and that report states, "Contagion or infection has had little or no share in the mortality; and I must beg to add, that it has never occurred in a single instance to my observation."

The remittent and yellow fever rages in some parts of the East Indies as well as in the West Indies, yet the most intelligent officers have never remarked any appearance of fever from "a specific or contagious source in India.". The evidence of the non-contagious nature of these diseases is equally strong on the continent of America. In the United states the fever hospitals have been built two or three miles in the country, and entirely beyond the local contaminated atmosphere of their respective cities. But in none of these establishments is there a single example of a person employed about the yellow-fever patients being attacked with this disease, unless he had been previously in an infected district. This appears to be so absolutely the case, that the President of the United States announced to both Houses of Congress in 1805, "That in the course of the several visitations of this disease, it has appeared that it is strictly local, incident to cities and tide-waters only, and incommunicable in the country, either by persons or by goods."

In addition to this testimony, many physicians, surgeons, and nurses have received the black vomit on their hands, faces, and clothes; some have inoculated themselves with it, and others have swallowed it, and yet no ill consequence has resulted. Beds, also, on which the yellow fever patient has died, have been occupied, still unpurified, by persons in health or patients labouring under other disease, and yet no unpleasant consequence has resulted. There seems no ground, therefore, for entertaining, in the remotest degree, the doctrine of the contagious nature of paludal fevers.

The only preventative treatment, therefore, is to avoid those localities which engender the paludal poison; and in Rome this precept is so well known that the wealthy inhabitants leave that city to reside during the summer in the country; while in Jamaica, from July to October, the only chance of avoiding an attack, in certain districts, is an early removal to the mountain residences in the interior. If, however, change of place is impossible, and we are obliged to reside within the range of the miasmata, we ought to avoid exposing ourselves to the night air, especially if we have previously suffered from the disease, for the tendency to relapse is great. It should also be remembered that a relapse commonly takes place on days corresponding to the paroxysm; hence great caution is necessary to avoid exposure to cold, fatigue, improper diet, easterly winds, great mental anxiety, or other excitement on those days. Europeans embarking for the West Indies should remember that the autumn is the sickly season, while January, or the beginning of winter, is the season of greatest health, and affords the greatest chances of the constitution becoming *acclimatée*. The adoption of these precautions must undoubtedly diminish the chances of attack, but the only true preventive is drainage, and, where that cannot be effected, the keeping the waters of the marsh up to a given level by means of flood-gates or other mechanical contrivances.



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### Of the Paludal Poison.—*Dysentery.*

It has been seen that the paludal poison, according to its intensity, produces the various forms of intermittent, remittent, and of yellow fevers; but so singular are the laws of this noxious agent, that fever is not the only disease which it inflicts on the human frame, for, owing to some modification either of quality or quantity, the miasm also gives rise to dysentery, a disease which consists of an inflammation of the mucous membrane of the colon, and whose course and phenomena are frequently unaccompanied by any febrile symptom whatever. It is doubtful, indeed, if the morbid actions of this poison end here, or whether many forms of hepatitis and of splenitis ought not to be referred to its baleful influence. It is now intended, however, to treat of dysentery only.

*Remote Cause.*—It may be stated, as a general proposition, that there is no country where paludal fever exists that dysentery is not an endemic and prevailing disease. In the East and West Indies, in China, the Ionian Islands, Gibraltar, Malta, the Canadas, Holland, the coasts of Africa, as well as in many different parts of France, of the Peninsula, of the continent of America, and of the eastern parts of Great Britain, the prevalence of intermittent fever and of dysentery is notorious. This connexion is so intimate that a given number of persons being exposed to the action of paludal miasmata, as a boat's crew sent ashore in a tropical climate, the probabilities are that on the men returning on board part will be seized with dysentery, and part with remittent fever.

Paludal fever and dysentery, moreover, are not only conjoined in locality, but they often also co-exist, precede, or follow each other in the same individual, so that the fever frequently ends in dysentery, and the dysentery in remittent fever. This proof of the common nature of these diseases is corroborated by every writer of any celebrity, and more especially by those who have detailed the diseases of our armies. It seems distinctly proved, therefore, that dysentery is a disease of a specific nature, and originates in some peculiar modification of the paludal poison. It seems also determined that dysentery prevails generally in the inverse ratio of the intensity of paludal fever. In Jamaica, for example, where the white troops suffer in the large proportion of 91 per cent. annually from paludal fevers, the cases of dysentery are to those of fever as one to nine; while in the Madras presidency, where the troops suffer from fever in the much less ratio of only $30\frac{4}{10}$ per cent. annually, the cases of dysentery are to those of fever as 47 of the former to 30 of the latter. It appears also that dysentery is less common in the hotter than in the colder months, or arises under circumstances less favourable to vegetable decomposition. Thus in India and China it is from the middle of November to the latter end of February, or when remittent fever changes into intermittent, that dysentery greatly prevails.

*Predisposing Causes.*—Our knowledge of these causes is derived from what principally occurs in the military and naval service; and from the sufferings of the troops we learn that exposure to the night air, to wet, or to fatigue, together with the intemperance and improper diet incident to the life of a soldier, especially on active service in the field, have at all times been found to be powerful predisposing causes to dysentery.

The effects of *salt* diet in the production of dysentery being less known than the other predisposing causes, it may be as well to state, that by an experience of 20 years in the West Indies, it has been determined that in the Windward and Leeward Command, where the rations issued to the troops consist of salt provisions five days in the week, the mortality from diseases of the stomach and bowels among the officers is as two to four per cent., while that among the soldiers is as 20·7, or a tenfold ratio. On the contrary, in Jamaica, where salt provisions are issued to the troops only two days in the week, the mortality from the same diseases approximates so nearly between these two ranks as to be almost an equality. And corresponding facts to these have been observed in Gibraltar, on the coast of Africa, and at St. Helena.

In the navy also the same effects of ill-regulated diet have been observed. "In 1797," says Dr. Wilson, "the victualling (of the navy) was changed, greatly improved, and consequently immediate to the change the health of the seamen improved strikingly. Scurvy, typhoid fever, *dysentery*, and ulcer, which, up to the period of the change, had produced great havoc, became comparatively rare in occurrence and light in impression," and, it may now be added, are hardly known except by name.

The last appearance of dysentery in London was apparently owing to an insufficient diet, and occurred at the Penitentiary, Milbank, shortly after its completion. This prison is built on a marsh below the level of the Thames at high-water, the river being banked out by a narrow causeway. As long as the prisoners were allowed a full and ample diet they appear to have resisted the action of the paludal poison, and to have enjoyed good health. No sooner, however, was the quantity and quality of their dietary lowered than dysentery of a very fatal character broke out, and made it necessary to clear that establishment for a time of all its inmates.

There are few facts to enable us to determine the proportions in which the different ages suffer from dysentery, but the returns of the troops from the Mauritius show that the mortality from this disease falls principally on soldiers advanced in life.

| | AGE. | | | |
|---|---|---|---|---|
| | 18 to 24 | 25 to 33 | 33 to 40 | 40 to 50 |
| Aggregate strength of 7 years | 3892 | 5361 | 1215 | 300 |
| Died of Dysentery | 26 | 63 | 24 | 8 |
| Ratio per 1000 of mean strength | 6·7 | 11·8 | 19·7 | 36·6 |

*Infecting Distance.*—The paludal poison, when it produces dysentery, is subjected to the same laws as when it produces paludal fever. It is *absorbed* by the same tissues, *co-exists* with the same poisons, and the human

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frame, instead of having its *susceptibility exhausted*, is unhappily liable to repeated attacks of dysentery, as well as of other forms of paludal disease.

*Period of Latency.*—The time which the poison lies latent in the system before it produces this form of disease is probably as various as that which precedes paludal fever. In many instances a large army has been affected in a few hours, while, from the many cases which occur on shipboard, and at long dates after the ship has left the land, it is probable the extreme periods may vary from a few hours to a few weeks, or even a few months.

*Pathology.*—The theory of this disease is, that the paludal poison, in a less dose than that which produces the mildest form of paludal fever, is absorbed by the mucous membranes and infects the blood, and after a given period of latency causes dysentery or inflammation of the mucous membrane of the colon. In a few cases likewise, either from continuity, sympathy, or a specific action of the poison, the mucous membrane of the stomach, or of some portion of the small intestines, becomes occasionally involved in the disease. The liver and spleen are also occasionally the seat of inflammation and of abscess, but whether from sympathy or a specific action of the poison is not determined.

The inflammation of the mucous membrane of the alimentary canal in dysentery may assume any form and degree incident to their structure, as the diffuse, the serous, the adhesive, the purulent, and the ulcerative, and it is not unusual to find most of these different degrees existing in different parts of the alimentary canal at the same time. These inflammations may also attack either the free or the adherent surface of the mucous membrane, or else its glandular structure; and these different parts may be either separately or conjointly effected. The pathological phenomena, however, vary in some degree, according as the patient falls in the acute or chronic stages of the disease.

When the patient falls in the acute stage of dysentery, or within the first few days of the attack, and while he is yet passing blood, mucus, or a loose watery lymph, or all of them, but before pus has appeared in the stools, the mucous membrane of the colon is found to be diffusely inflamed in patches varying from a shilling, or the palm of the hand, till the entire surface of the colon is affected. The colour of the affected part is of a deep cherry or venous red, and in some instances so nearly approaching to black as to appear sphacelated. This membrane is also thickened, and its cohesion so impaired that it appears almost gelatinous. The diameter of the intestines is also contracted.

The glandular structure of the alimentary canal is not necessarily affected in dysentery, still it is more commonly diseased; and in such cases the follicles are either enlarged and transparent, or else enlarged, hard, and opaque, according to the degree of inflammation. The contents of the colon in this stage are blood, mucus, and a loose watery lymph, together with a small portion of fæcal matter. Many early writers speak of having found scybalæ in large quantities, but modern observation has shown this circumstance to be extremely rare. The mesenteric glands are gorged, but seldom enlarged in this stage, while the mesentery itself often presents many red points, evidently the result of inflammation.

The second stage commences when pus appears in the stools. In this country suppuration seldom takes place without ulceration; but it is not improbable, from the quantity of pus passed by stool, sometimes many ounces, that pus may be secreted without ulceration: and Dr. Cornuel states he has examined cases in Guadaloupe in which no ulceration has been found, and yet pus in considerable quantity was contained in the colon. In this country the pathological character of the second stage is ulceration of the mucous membrane, and very commonly also of its glandular structure. The ulcers are usually situated at the free surface of the membrane, and they usually first appear as a number of small points, intensely red, which soften, and ultimately ulcerate. The ulcers may be deep or superficial, and their edge may be sharp and defined, as if made by a punch, or else broken down and almost diffluent. In dysentery, says Chomel, the mucous membrane often presents an appearance of erosion, which is an illusion; for if we gently pass the handle of the scalpel over it we detach a reticulated false membrane, and find the mucous membrane below it red and softened, something like gooseberry jelly.

As the disease advances the extent of ulceration is often quite astonishing; the whole of the mucous membrane, from the cæcum to the rectum, seems one universal series of ulcers, of which a few are occasionally found cicatrized, while others, perhaps, have burrowed so deeply as to rupture the peritoneal coat. The whole intestine is also thickened, contracted, and firmer than natural.

The adherent surface of the mucous membrane is rarely inflamed in the acute stage beyond that degree which impairs its cohesion. In the second stage, however, it is frequently the seat of a number of small abscesses, which give to the intestine that tuberculated appearance described by Pringle. The mucous membrane covering these abscesses at length inflames, softens, points, and bursts, and the pus escaping, abscesses of considerable depth are formed, and often in large numbers. The glandular structure is also frequently concomitantly affected and ulcerated.

When the small intestines partake of the inflammation the lower portion of the ilium is the part most commonly effected; and the mucous membrane of that part is either of a deep venous colour, or else *ardoisée*, according to the length of the disease, and it may at the same time be indurated or softened, thickened or ulcerated. In one case, Dr. Cheyne says, he found an exudation of lymph extending nearly over the whole of the jejunum.

If the stomach participates in the disease the mucous membrane may be merely diffusely inflamed, or of a red or violet-colour, its surface granulated, and its texture broken by the slightest touch. More commonly, perhaps, the colour of the mucous membrane is natural, but on its surface a number of ecchymoses or else small ulcers are seen with edges as sharp, clean, and perpendicular as if made with a punch.

The peritoneum, unless it has ruptured, is seldom either inflamed or thickened, but often presents many injected or ecchymosed points, which, when the intestine is opened, prove to be the base of some deep-seated ulcer. If the disease has terminated in dropsy the peritoneum is then commonly white, opaque, and thickened, or else injected, and perhaps granulated, the cavity containing a large quantity of albuminous serum.

The mesenteric glands are often found enlarged, red, and softened, sometimes resembling a clot of half fluid



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blood, and sometimes they are said to have been met with as black as charcoal.

Sir James Macgrigor examined 22 bodies that had died of dysentery in the East Indies, and found the liver diseased in sixteen; and from this and similar circumstances, many pathologists have inferred that the liver was in all cases primarily affected, the dysentery being merely an accident, and caused by obstruction of the portal system. In the Peninsular war, however, the liver was often found free from the most trifling appearance of disease. At other times, indeed, it was altered in colour, but not changed in structure; and again, its colour being natural, its structure was found diseased, the viscus being either larger or smaller than usual, and indurated or softened, and sometimes the seat of abscess.

The spleen and pancreas are sometimes found diseased; and Mr. Twining notices the former as one of the most fatal complications of dysentery in the East Indies. These viscera are found either enlarged and softened, or enlarged and indurated, the spleen being sometimes the seat of abscess. It seems probable that the diseased states of the spleen must be owing to a specific action of the poison, for there does not appear to be any necessary connexion between that organ and the colon.

*Symptoms.*—Dysentery is divided by all authors into two stages. The first stage is that which precedes the appearance of pus in the stools. The second commences with the appearance of pus. The first stage is usually short, and seldom exceeds ten days or a fortnight, while the second stage may last from a few days to many months. It is important to mark this division into stages; for the chance of being able to cure this intractable disease depends on our being able to arrest it before the appearance of pus.

It is remarkable that a disease so fatal should in the first instance cause little disturbance of the constitution, so that fever is seldom present, and is always moderate when it is so. Dysentery is therefore essentially a *colitis*, and for the most part the symptoms are local. Its attack may be sudden, and the disease ushered in by a short rigor, but more commonly it is preceded by some diarrhœa, or a few bilious stools, causing a burning sensation of the anus.

The preliminary stage passed, the stools become more numerous, often 10 to 20 in the 24 hours, and according to Dr. Cornuel, sometimes in the West Indies they amount to upwards of 200 in the same period, the patient being incessantly "*sur le siége.*" The stools are passed in general with great effort, and consist of mucus, or a white glairy matter mixed with blood. By degrees the quantity of blood increases, till at last a pure black blood of loose consistency, and having sometimes a peculiar fœtid gangrenous odour is passed. This excretion is accompanied by much pain or tormina of the abdomen; by great tenesmus, and by great efforts at defæcation, so that at length procidence of the rectum may take place, and greatly add to the sufferings of the patient. In the West Indies, according to Dr. Cornuel, portions of mucous membrane, varying from a few lines to a few inches, are often passed in this stage, in a gangrenous state, when the abdomen becomes tense, meteorized, irritable, and the patient has an incessant desire to pass urine, which is always scanty, high coloured, and sometimes suppressed.

Inflammation, however, when strictly limited to mucous membranes, is not necessarily accompanied by pain, so that the patient is occasionally destroyed by acute dysentery, without suffering any abdominal pain. Pain, however, is a symptom which frequently exists, sometimes slight and transient, and relieved by pressure; at others severe and constant, and increased on pressure. Its more usual seat is the umbilicus, occasionally above or below it, or else to the right or the left of the mesial line; it often also extends down the thighs. The different complications of amount of pain, and number of stools, &c., cause dysentery in different countries, and in different persons in the same country, to vary from little more than diarrhœa, to the severest forms of colic, or even of cholera.

If the patient recovers, the symptoms are mitigated, the pain ceases, the number of stools diminish, and the flow of urine is restored. On the contrary, if the disease terminates fatally in this stage, hiccough, vomiting, a small and rapid pulse, and pale sharp features, denote the impending close of the disease. The intellect, however, is perfect, and the patient, often deploring the fate which he sees inevitably to await him, dies after a short agony.

At the end of a few days, however, pus may be seen in the stools, and the second stage be formed, and the patient is now plunged into the greatest danger. The pus passed in mild cases is often small in quantity, but more commonly it amounts to several ounces in the 24 hours, and may be voided with or without fæcal matter, blood, shreds of lymph, and lumps of a sebaceous substance, the number of stools continuing unabated. It is singular for how long a time the patients met with in London continue to possess much embonpoint, appetite, freedom from pain, and from all constitutional affection, notwithstanding the long-continued action of so powerful and exhausting a disease. At length however, the scene advances to a close, and the stools become more frequent, the tenesmus more distressing; pain, perhaps up to this period altogether wanting, becomes severe and constant, and occupies a large extent of the abdomen, or else perhaps an abscess of the liver silently forms without pain, and the first indication of its existence is its pointing, and the sinking of the patient. Whichever of these events takes place, the patient becomes rapidly altered and broken by his sufferings, is strikingly emaciated, and often earnestly prays to be relieved from a life disgusting to himself and entirely despaired of by others. On the contrary, the patient in a very few rare instances recovers, the local symptoms gradually yielding, till his health and strength are ultimately restored.

*Diagnosis.*—It is difficult, perhaps impossible, in the first stage, to distinguish dysentery from diarrhœa; but the blood, the number of the stools, and small quantity of fæcal matter passed, will, in times when dysentery is prevalent, allow the calm observer very closely to approximate to the true nature of the disease. When pus appears in the stools, unless some fistulous or other abscess has burst into the intestine, there can be no doubt of the nature of the affection.

*Prognosis.*—The prognosis depends much on the country in which the disease occurs, but in hot climates it is calculated that only 1 in 20 or 25 falls. On actual service these chances are much diminished. In the chronic forms it is supposed that three out of four recover; but this is a proportion much more considerable than is obtained in the London hospitals.

*Treatment.*—Perhaps there is no question on which

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the profession are so much agreed, as on the inutility of large bleedings in dysentery. There are many authors who, with many limitations, recommend one general bleeding; but in almost every writer we find local bleeding the rule and general bleeding the exception; while many physicians omit both these operations.

As quina is unquestionably a specific remedy in the cure of the milder and uncomplicated forms of paludal fever, it might be presumed to have a most direct and beneficial influence in the cure of dysentery; but so singular are the laws of the paludal poison, that as a general rule, its exhibition in any form or quantity, and in any stage, has proved rather injurious than sanatory.

The favourable and almost specific actions of mercury in many of the secondary actions of the paludal poison make an investigation into the effects of this substance in the cure of dysentery a matter of much interest, especially as it has been extensively used, and in many cases with unquestionable benefit. We regret, however, that much difference of opinion exists as to the circumstances under which it should be administered. Some prescribe it in the acute stage, others restrict its use to the chronic stage, some give it in every stage, while others think it ought to be withdrawn when the tormina is relieved. Some also give it in scruple doses, others more moderately, but push it till the mouth is affected, while others give it only in small doses. In the midst of all this confusion Sir James Macgrigor seems to think this medicine is applicable only to the dysentery of particular countries, and that the dysentery of India and of Europe are different diseases,—dysentery being readily cured by calomel in India, while in the Peninsular war, that medicine was only decidedly useful in dysentery complicated with liver complaints. If given under other circumstances, or in the early stage and before venesection, or in the more advanced stage, particularly when there was hectic, with extensive erosion or ulceration of the intestine, it was invariably found to aggravate the symptoms and to hasten the fatal termination. Ipecacuanha also was formerly much in vogue as a specific in the treatment of dysentery, but it has no pretensions to any such property. It follows that neither bleeding, quina, or calomel, are antidotes to this form of paludal disease, and consequently that there is no exclusive plan of treatment applicable to all cases. Admitting, therefore, the necessity of occasionally employing general and local bleeding, and also calomel, in cases of hepatic complications, we have beyond this only the general principles to guide us of allaying irritation and of controlling, if possible, the diarrhœa; and the best general rules that we possess are those recommended by Sir James Macgrigor to be adopted in the army, and acknowledged by him to be derived from Dr. Somers.

"We commenced," says Sir James Macgrigor, "by copious venesection, and immediately afterwards gave pulv. ipecac. comp. gr. xij. every hour, which was repeated three times, with plenty of barley-water, and profuse sweating was encouraged for six or eight hours. A pill of three grains of calomel and one of opium was administered every second night, and in the intervening day ℥ ij. of sulphate of magnesia dissolved in a quart of light broth. The venesection was to be repeated while the state of strength and pulse permit it, until the stools are free, or nearly so, from blood, following up Dover's powder as a sudorific.

"In cases where the pains were excruciating and attended with tenesmus, the warm bath gave instantaneous relief. This plan being steadily persevered in for a few days the inflammatory diathesis of the intestinal canal, which had excited symptomatic fever throughout the general system, was found to relieve and make way for returning health. In this stage gentle tonics, with light nourishing diet cautiously exhibited, and at first given but in very moderate proportions, were introduced with the happiest effects.

"This disease was not unfrequently cut short by the above plan. If, however, the second stage advanced, and the disease became chronic, a different mode of treatment was pursued, and not unsuccessfully, if the disease had not been of long duration, the intestinal canal not much disorganized, or not complicated with other diseases.

"The first indication in this stage was to relieve the tenesmus and procure easy stools, and with this view Ipecacuanha was given, sometimes with calomel, sometimes without it. The neutral salts were given, or oleum ricini, jalap, and various other medicines of the same class. The second indication was, to relieve the number of the stools and to restore tone to the alimentary canal. With this view Dover's powder, pulv. cretæ comp. c. opio—astringents and demulcents, with aromatics, were given, occasionally interspersing laxatives, and obviating particular symptoms as they occurred. Lastly, an infusion of bitters was given to restore tone to the relaxed intestine."

In addition to these remedies Sir James Macgrigor states, that the balsam of copaiba, an infusion of Calumba, hæmatoxylum, kino, and catechu, assisted by opium occasionally, gave much relief, and also the throwing up a variety of enemata, and especially one of a strong solution of superacetas plumbi; while in cases of liver affection he adds, "that friction of the abdomen, with mercurial ointment, gave the least irritation, and at the same time produced less debility."

Such is a statement of the practice pursued in dysentery during the Peninsular war, and on a scale whose magnitude has seldom been surpassed, even in modern times. If, however, we look to the returns, we find it highly probable that not more than two out of three of those attacked ultimately recovered.

In general the dysenteric patient is not admitted into the London hospitals until the disease has passed into the second stage; and in candour it must be allowed there is no class of disease which offers so few chances of recovery. On the Continent the neutral salts and mild purgative medicines are highly spoken of; but it is difficult to understand how these substances, having no specific power over the disease, can be beneficial in a highly ulcerated state of the intestine. Of all the purgatives, however, two ounces of an infusion of ipecacuanha, ℨ j. to lb. j. of boiling water, combined with ♏v. to ♏x. of the tinc. opii, and exhibited every six or eight hours, appear to be best; but the disease, though mitigated, is seldom cured by this means. Mercury also, in whatever dose or form exhibited, has not appeared to take up the disease, or only temporarily to benefit the patient. Vegetable tonics, containing tannin, as kino, hæmotoxylum, or catechu, however prepared or combined, give temporary relief, but are ultimately inefficient. The mineral acids are also seldom useful. Among the mineral astringents the sulphate of copper has been much spoken of; but during the Walcheren expedition, when it was prescribed, from some supposed

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virtue, for the cure of intermittent fever, its use was abandoned, on account of the severe diarrhœa which followed its exhibition. Enemata, it may be stated, of whatever description, have almost universally failed even in relieving the patient. Of the remedies less known and less used, the salicine in doses of five grains every four, or every six hours, appears to have the property of curing the milder forms of dysentery, when opiates give but little relief. A few cases have been treated in St. Thomas's Hospital, by balsami Canadensis, gr. v. opii gr. fs 6tis horis, and the patients so treated have recovered. Dr. Fahnestock, of Pittsburgh, says he treated from 60 to 80 cases of well-marked dysentery, after preliminary purging with calomel or castor oil, with 3 fs. of spiritus terebinthinæ, and that a very large proportion recovered.—*Med. Gaz.* Feb. 1844.

*Dietetic and Preventative Treatment.*—The patients should be limited to slops, milk, broths, and at most a fish diet, with a small quantity of wine or brandy. They should carefully avoid cold and wet and night air. In paludal districts they should also be warmly clad.

### Of the Poison of Cholera Indica.

The formidable disease to which this poison gives rise is remarkable for its sudden and great eruption in Bengal in 1817, and for its subsequent fearful spread not only over the Peninsula of India, but also over the greater part of the habitable globe. The medical history of India is so imperfect, however, being up to 1774 limited to *two private letters*, written by Dr. Paisly, copies of which were in the hands of most of the older surgeons practising in that country, and to the imperfect works of Bontius, that many persons have doubted whether this peculiar disease is or is not of secondary formation.

There are traces of cholera in India, however, in the most ancient records of the Brahmins. While Mr. Curtis has given an account of a disease which he witnessed in the years 1782-3, both at Madras and Ceylon, so perfectly identical with the cholera Indica of the present day, that there is no question that this disease must have existed occasionally endemically or epidemically in India at former periods. The remarkable fact, however, of its spread from India generally over the globe, and at all seasons of the year, is an entirely new circumstance in its history.

*Remote Cause.*—The remote cause of this disease is unquestionably a poison, for at no former period has a person in good health in this country been known to become in a few minutes shrivelled up; his whole body to be of an icy coldness; his face and extremities to turn purple, and with or without vomiting of a peculiar fluid like rice-water, to die in a few hours. Neither is it explicable on any other hypothesis than that of a poison that this disease should spread over countries, which, in respect to climate, soil, geological formation, and also to the moral and physical habits of the population, are the most opposite to those where it first originated. Assuming, therefore, that Cholera Indica is produced by the action of a poison, whence does it originate, and how is it generated?

This disease having broken out in the Suderbunds or low country of Bengal, it has been supposed that the poison has a paludal origin. The hypothesis, however, of this poison having a paludal origin seems untenable, for the disease it gives rise to does not follow the ordinary laws of paludal diseases, since Cholera Indica has prevailed in districts far remote from every source of marsh effluvia, spreading to countries of entirely different formation, and raging in seasons when paludal diseases cease to exist. It has been said, however, that this is a peculiar poison, generated in marshy countries, and giving rise to a disease which spreads by contagion. Still it will be shown hereafter, that on no point are the profession more agreed than on the non-contagious nature of Cholera Indica, a disease which continues to prevail in India with great violence, and yet has shown no similar tendency to spread.

If we look to the circumstance of Cholera Indica spreading over all countries and at all seasons of the year, the hypothesis of the poison having a telluric origin is much more accordant with the facts.

Thus, if we suppose it to be generated below the crust of the earth, and consequently beyond the influence of the atmosphere, it is easy to understand why its course is entirely independent of the seasons. Again, if we suppose it to have in any degree a central origin, this circumstance will readily explain why the miasmata, percolating with different facilities the different superincumbent strata, may burst forth at distant and remote places, forming new centres or foci of the disease, although the general course of the stream may be uniform. We can readily understand, also, on this hypothesis, why it may affect particular lines of country, as the banks of rivers, the soil lying more loosely and lightly in their neighbourhood.

Some physicians have imagined, from the streams of the poison having sometimes diverged at right angles to each other, or else proceeding east and west, have trended to the north or south, that the poison, if not the electric or magnetic fluid itself, must be extricated by their agency. This may perhaps be the case, but electricity certainly is not the poison itself, for cholera has been observed to rage in every country under very different electrical condition of the atmosphere, and equally when that element has been in a state of equilibrium, and when it has been most disturbed.

The history and habits of this poison, independently of its action on the human frame, are extremely interesting. It is sporadic and epidemic; and its epidemic progress is as follows:—

The progress of epidemic Cholera Indica, in 1817, is extremely remarkable. It originated in Jessore, and the country around that city in August, 1817, whence it spread east and west. The western branch proceeded towards Calcutta, and after devastating that city, continued its course along the Ganges, till it reached the grand army, about 400 miles from Calcutta, and assembled on the banks of the Sinde, in expectation of a war with the Pindarees. Having reached that point, it penetrated southward into the Peninsula of India, in three great streams. The first proceeded from Calcutta along the Coromandel coast, till it reached Madras, while the other two proceeded from the army as from a centre along its lines of communication, till the one reached Madras, the other Bombay—each town in its path becoming infected, and constituting a new focus, whence the disease spread all around. Having reached the two southern presidencies, it continued its rout southward along the Malabar and Coromandel coasts till it reached Ceylon, and from Ceylon it advanced to its extreme southern limit, the Mauritius.

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The cholera does not appear to have spread to the westward of India for about three years; but in July, 1821, or shortly after its re-appearance in Bombay, it broke out at Muscat, Busheer, and Bussorah, the three principal ports of the Persian Gulf. From those points two principal streams arose, or one which, proceeding westward, reached the Syrian shore of the Mediterranean in 1823; while the other advanced northward, till it reached Astrakan in Europe, a port on the Black Sea, and situated at the mouth of the Volga. At both these points, however, the disease now died away.

The progress of cholera eastward was as formidable and as remarkable as that westward. From the coast of Coromandel and Ceylon, the cholera, in 1817, crossed the bay of Bengal, broke out on the opposite coast of Arracan in 1818, reached Penang in 1819, and made its way through the Indian Archipelago, devastating Java and the Spice Islands, till it reached Timor, its extreme south-eastern limit. In the Philippine Islands, the malady was marked by one of those terrific outbreaks of barbarian violence which have more than once added to the terrors of this pestilence. The natives accusing the Chinese and Europeans of magic, and of being the authors of the disease, rose upon them, and 15,000 lives are said to have fallen in the struggle. In its progress to the northward it reached Canton in 1820, and Pekin in the following year, and committed great ravages in the populous empire of China. Having thus reached its extreme eastern limit, the stream passed the northern wall, took a retrograde course, passing through Tartary, desolated many parts of Mongolia, and at length reached Oreoberg, a Russian city, situated on the Tartar frontier, about 400 miles north of the Caspian sea, in 1829; but whether this stream subsided altogether, or survived till 1831, is not determined.

The progress of cholera did not attract the attention of Europe till the year 1829, when again it established itself in Astrakan, by the revival of the western branch, and by the arrival of the eastern branch. The disease, however, once more died away in that city; but in 1831 it again returned, breaking out for a third time in Astrakan, on the 20th of July. Its re-appearance in this quarter forms a new epoch in the progress and history of cholera, for it now pursued its course throughout Europe, and, in addition to its cold stage, now came armed with a severe and fatal fever, which had not been observed, or but rarely, in India.

The European stream, as it may now be termed, formed two branches, one of less moment, which spread westward into the Cossack country, while the other extended up the Volga till it reached Moscow, in September, 1831. Moscow now became a new centre of infection, from which three more principal branches streamed over this country; one taking a northerly direction reached Archangel, in May, 1831. Another accompanied the Russian troops in their invasion of Poland, while another passed along the route to St. Petersburg, which capital, notwithstanding numerous cordons of troops, it reached in the month of June, 1831. The disease from these two latter points continued to spread westward till Warsaw became affected, and from this city, as from a new centre, it again progressed westward, following the usual law of adhering to the great roads and banks of rivers, till it reached Berlin and Vienna; the former capital being attacked in August, 1831, and the latter in September of the following year, and from these points it gradually spread nearly over the whole of Germany to the east of the Elbe, till among other places it reached Hamburg; and the next new focus after Hamburg, in spite of a rigorous quarantine, was the port of Sunderland, on our own shores; no continental port westward of the Rhine being yet affected. The first case of cholera observed in England, was on the 26th of October, 1831. From Sunderland it spread north and south, and reached Edinburgh, on the 6th of February, 1832, and London on the 26th of the same month, while it infected Dublin about a month later, or on the 22nd of March, 1832. The cholera having now reached the extreme point of western Europe divided into two branches, one of which pursued its course westward till it reached America, while the other retrograded to the south-east, and invaded France, Italy, and the coast of the Mediterranean generally, as far as Malta. It also attacked Spain, Portugal, and the north-western coast of Africa, when the disease, though still prevalent in India, died away. Such is a slight sketch of the progress of cholera, a course in no degree dissimilar to that observed in the progress of the various influenza which have so frequently and so extensively affected the world.

In pursuing its course, the poison of cholera appears to have been developed in two different manners, probably according to the nature of the country, sometimes forming one or more centres, from which the disease radiated in every direction, and again running in lines of no great breadth, the country on either side being healthy. The instances of its acting eccentrically were many, as at its outbreak at Jessore and Calcutta, and also at London and Paris, the country around those capitals being extensively infected. The examples of its acting in lines or belts are also numerous. In the case of the attack on the camp of the Marquis of Hastings, the space of 50 miles, made the difference between exemption from the disease or death. There were also in India many instances of corps marching in parallel lines at small distances from one another, and keeping up the most free communication, and yet in the one the cholera has been raging, while the other has continued healthy. Also, sometimes after running a long course on one side of the Ganges, it would, as if arrested by some unknown agent, at once stop, and, taking a rapid sweep across, lay all waste on the opposite bank. The same fact was also observed in Canada. In other instances, the disease would sometimes take a complete circle round a village, and leaving it untouched, pass on as it were wholly to depart the district. Then after a lapse of a few weeks or even months, it would suddenly return, and scarce re-appearing in the parts which had undergone its previous ravages, would nearly depopulate the spot which had so lately congratulated itself on its escape. Again, in its progress along the Ganges it passed over many large towns and cities, as Banda, Allahabad, and Benares, places which lay in the direct route from Calcutta to the camp of the Marquis of Hastings, and then, like a receding wave, only the more heavily fell on them the following year.

In some fortunate instances the country over which the cholera has thus passed has escaped altogether. Hanover, for example, with the exception of Lunenburg, escaped, as did also the principal towns in Saxony, as Leipsic and Dresden. Weimar, Gotha, Anhalt, Hessia, Brunswick, Mecklenburg, and Bavaria, likewise escaped the disease, as did many countries to the south

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of Vienna, as Carinthia, Stiermark, and the Tyrol, though surrounded by infected districts.

We have seen that the great streams of cholera on the whole steadily advanced in their course, but they did not proceed at an uniform pace,—the rate of progression varying in different countries. In the year 1817, the cholera had overrun in India, in three months, a space westward of not less than 400 miles, while to the south it had penetrated no farther than Ganjam, only 88 miles from Calcutta, in six months. In the next six months, however, it had extended in a southerly direction over more than four-fifths of the Peninsula. It reached Pekin about the same time it attacked Muscat, the former being twice the distance of the latter. In Europe its progress was equally capricious. It travelled from the Caspian to Vologda and Pskou, within 100 miles of the Baltic, at a rate which would have infected all Europe in three months, while it did not reach Riga, only 180 miles distant from the latter town, till eight months after. Its rate, however, appears to have been most retarded in its retrograde movement; for it took six years after London was infected to reach Rome, and about seven years to travel from Pekin to Astrakan. In a word, it took only one year to span the base of the Peninsula of India, while it occupied 20 years' to compass the globe.

In Europe, and also in India, cholera has prevailed in all seasons, at all periods of the year, and under every degree of heat or cold, of dryness or moisture. It is remarkable, however, that there is in India a period termed the cholera season. In Bengal, for instance, this season usually begins with the heats of March and April, when the cases are few; in May, the disease is generally at its height, and is more or less epidemic, while in June and July it begins to decline, and on the setting in of the cold weather, in October, it so far disappears, that the cholera season is said to be terminated for that year.

Although the cholera has raged in countries of every altitude, has devastated the high table lands of Nepaul, and even attacked the medical depôt at Landorn, situated 8000 feet above the level of the sea, a height which in Europe is almost the region of perpetual snow, yet in general it follows a law common to many other epidemics, or a marked disposition to affect low marshy situations and the banks of rivers, while healthier and more elevated tracts have been more slowly attacked, and more quickly freed from it.

The last remarkable circumstance we shall notice relating to this poison, and which is perfectly inexplicable, and not known to be common to any other morbid poison, is, that in Europe and America the disease has been accompanied by a series of new and terrible symptoms, unknown, or nearly so, in India, a second or febrile stage being added, and which most commonly destroyed the patient after he had successfully struggled through the cold stage, as if the poisons of cholera and of typhus fever had conjoined, forming a new compound which had the deleterious properties of both diseases.

*Predisposing Causes.*—The deaths from cholera in Paris were estimated at 18,402, and it was remarked that all *ages*, including new-born children, were liable to this disease, but that the mortality was least from 6 years to 20, greater from 30 to 40, and greatest of all in old age. The influence of *sex* in predisposing to cholera can hardly be said to be determined; for in Calcutta, of the native inhabitants attacked with cholera, the males were to the females as four to one, while in Bombay the proportion was as 7 to 25. In Canada the soldiers' wives were observed to suffer nearly in an equal proportion with their husbands; and this was the case among the civil inhabitants of Gibraltar.

In all countries the *lower classes* have always suffered in a much greater proportion than the upper classes. In Calcutta the disease ran a wide career of destruction in the native town, while the "City of Palaces," inhabited by the English, was much less affected in proportion to their numbers, and the same disproportion has been observed, in Bombay. In general also it has been observed among the native inhabitants of India, that the Bramin and Banian merchant suffered less than the Ryot or farmer, while the poor outcast Pariah suffered the most of all. In every town in Europe also it has been observed that the lower classes, and especially those resident on the banks of rivers, have suffered infinitely more than the upper classes.

In military life it has been supposed that the Sepoy suffered more than the European soldier living in India. This perhaps is true in some instances; but the returns of the Madras army show this not to have been the fact in that Presidency; for the European soldiers attacked appear to have been as one to three, while of the Sepoy force it was only one in four and a half. In the Indian army also it appears to have been universally observed, that the officer suffered in a less proportion than the soldier, the cavalry than the infantry, and the infantry less than the hard-labouring ill-fed camp-follower. The troops on march likewise universally suffered more than the troops in quarters.

The effects of a poor diet will perhaps be better understood, by stating that the European suffers less than the Mohammedan, and the Mohammedan, who is better fed and better clothed than the Hindoo, except during their rigid fasts, when the Mohammedans suffered in a much larger ratio.

*Susceptibility exhausted.*—The actual number of persons attacked out of any given population appears to have varied very greatly. Mr. Scott has stated, that in the marching corps it has varied from 17 to 330 per corps of about 1000 men; and in no instance, even in all the wretchedness of the Indian towns, has the community suffered to the whole extent of the population. In Europe, Moreau de Jonnès has given the following estimate as an approximation to the probable numbers attacked in this part of the world: In France, 1 in 300; Russia, 1 in 20; Austria, 1 in 30; Poland, 1 in 32; Prussia, 1 in 100; Belgium 1 in 120; Great Britain and Ireland, 1 in 131; Holland, 1 in 144; Germany, 1 in 700. The circumstance of one attack by no means armed the constitution against a second in the same or any subsequent year; still a repetition of the disease in the same party in the same year was rare.

*Co-exists.*—The poison of cholera is capable of co-existing with many other poisons. Several patients were attacked while labouring under syphilis. One man labouring under small-pox was attacked, when the pustules immediately shrivelled and dried up. Typhus fever and cholera ran constantly into each other, and sometimes cholera terminated in intermittent. No disease has yet been remarked as giving an exemption to cholera.

*Modes of Absorption.*—We possess no data to enable us to determine by what tissue the poison is absorbed; but it is probably the mucous tissue, and infects the blood; for that fluid is found greatly altered, certainly

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in its constituent parts, if not in its chemical qualities.

*Period of Latency.*—The period of latency probably varies considerably, and in some instances it is extremely short. The King's 41st regiment arrived in two divisions from England at Madras, and within three days of their arrival the cholera was raging among them. The minimum of time is undetermined; but troops leaving their barracks perfectly healthy have been attacked after a few hours' march. Again, a vessel sailing from an Indian port has reached the line before the disease has broken out,—a voyage seldom performed in less than a fortnight.

*Pathology.*—The theory of this disease is, that a poison has been absorbed and infects the blood, and that after a given period it produces disordered action of the muscles or parts supplied by the spinal cord, also of the lungs or parts supplied by the eighth pair, and likewise of the alimentary canal generally, or parts supplied by the great sympathetic. Again, if the disease passes into the second stage, it produces in addition fever and inflammation of the membranes of the brain.

The depressing influence of this poison is so great that life has frequently been destroyed in a few moments, and not unfrequently in two or three hours. It will be plain, then, that a poison so powerful, so suddenly overwhelming all Nature's efforts at resistance, does not allow time in many cases for any secondary or specific actions to be set up. In those patients, therefore, who have fallen in the first stage, or within 48 hours of the attack, rarely has there been found any alteration of structure in any organ or tissue, unless the disease has been preceded by long-continued diarrhœa, in which case the follicular structure of the intestinal canal has been found to be enlarged, and the intestine filled more or less with a turbid, inodorous, semi-diaphanous fluid, usually compared to a thin starch or rice-water, the remains of that immense secretion which has taken place during life, and which, being tested, has been found sometimes acid and sometimes alkaline. A layer of greyish mucus has also been found coating the whole of the mucous membrane of the alimentary canal, but without a trace of bile, although the gall-bladder is usually filled with that fluid. If the first stage has been prolonged the mucous membrane of the alimentary canal is of a livid colour, and in some instances has presented a mammillated appearance, probably caused by an enlargement of the follicles; for, according to Dr. Budd, by drawing the coats of the stomach between the finger and the thumb, and using some pressure, a white opaque fluid is squeezed out, and the mammillated appearance effaced.

The liver, the spleen, and the kidneys, have in general been found gorged with blood, and this engorgement extends even to the bones, which, Louis says, appear as if the animal had been fed on madder. The bladder is contracted and empty. The membranes of the brain and cord are in general congested, and the substance of the brain dotted with more puncta cruenta than usual.

Such are the appearances which the body has presented, when the patient has fallen in the first, or asphyxieted, or pulseless stage; and the phenomena are said to differ in no respect from those observed in persons who have died in the first stage of intermittent fever, when the blood, driven from the periphery, accumulates in the central parts of the body. The enlargement of the follicles is supposed to be peculiar to those cases in which diarrhœa, or other disorder of the alimentary canal, had for some time preceded the fatal attack.

When the patient has survived until re-action has taken place, and the second or febrile stage has been formed, the body no longer presents that shrunk, worn, and livid appearance it did on death taking place in the first stage; but on the contrary, rather the fulness and plumpness of the fever patient. The injection of all the large organs has also disappeared, the blood being recalled to the surface of the body. The alimentary canal is no longer distended with the turbid secretion peculiar to cholera, but contains a thin yellowish *purée* of fæcal matter, having the usual odour. The mucous membrane of the alimentary canal has now, however, been found more or less diffusely inflamed, sometimes in all its divisions, but more especially of the pyloric portion of the stomach, and also of the duodenum. The Plaques du Peyer as well as Brunner's glands, though occasionally found enlarged, were seldom found ulcerated; but when that was the case the corresponding mesenteric glands were also enlarged, being sometimes pale or purple, and when cut into gave issue to a dark liquid blood.

The lungs have often been seen congested, and in the first stage of pneumonia, while the brain has presented the ordinary appearances of fever, or more puncta cruenta than usual, the membranes being often congested or inflamed, with the usual serous effusion into the arachnoid cavity.

*Symptoms.*—Cholera Indica has no varieties but many degrees, and hence many pathologists have divided it into Cholera Indica mitior, and into Cholera Indica gravior. The French have termed the slighter forms of the disease Cholerine.

The Cholera Indica is divided into two stages, or into the cold, pulseless, or asphyxiated stage, and into the hot or febrile stage. This latter stage, however, is not essential to the disease, and has been observed in India in a small proportion of the cases only. In Europe, however, the febrile paroxysm has followed in the majority of instances. The duration of the cold stage varies from a few minutes to 12, 24, 48, or even more hours, while the hot stage lasts from four to eight or more days, making the total duration to vary from a few minutes or a few hours to two, three, or even four weeks.

The attack of this fatal epidemic is most commonly sudden, the patient at the time of his sickness being apparently in his best health; yet not unfrequently slight diarrhœa or other general indisposition has preceded it. In India in some cases the premonitory symptoms are vertigo, noise in the ears—the latter sometimes so loud as to have been compared to the humming of a thousand swarms of bees, to the beating of all the drums in the camp, or to the roaring of the surf on the Coromandel coast.

The disease being formed, the suddenness with which the poison sometimes extinguishes life is extremely remarkable. When the cholera reached Muscat, instances are given in which only ten minutes elapsed from the first seizure before life was extinct. In one instance a Jew merchant was closing a bargain, when he suddenly vomited twice, fell down, and expired. Many natives at Hoobly were attacked while walking in the open air, and having retched, complained of vertigo,



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blindness, or deafness, fell down, and expired in a few minutes. At Punderpore also the disease is said to have been fatal in an equally short time, so much so that 350 persons are reported to have died in the streets, "tombling over each other lifeless," or, according to another authority, "as if knocked down dead by lightning." Instances of death taking place in two, three, four, or more hours are extremely common. The more usual course of the disease, when limited to the cold stage, is as follows:—

After the patient has been troubled for a few days with diarrhœa, but more commonly while he is yet in perfect health, and has retired to rest, and has slept soundly till the middle of the night, or far onwards till morning, he is suddenly seized with a most unaccountable sickness and vomiting, together with a most profuse discharge from the bowels. These evacuations are attended with most severe pains down the thighs, and more especially by an indescribable and subduing sense of exhaustion, the patient often fainting in the water-closet. In an instant not only are the physical powers of the body exhausted, but its temperature sinks rapidly below the natural standard, and an icy coldness benumbs it; while the skin is sometimes rendered so insensible, has so lost its vitality, as to resist even the action of boiling water or other powerful chemical agent. The breath also, as it issues from the mouth, has a glacial feel. Still, notwithstanding this great loss of temperature, the patient complains of being oppressed with heat, is incessantly throwing off the bed-clothes, and cold water is grateful to him, copiously and eagerly drank, yet affording no relief to his insatiable thirst.

The extreme coldness of the first stage is further accompanied by a blue, livid, or purple discoloration of the hands and feet, extending not only a considerable way up the arms and legs, but sometimes over a great part of the body. These parts often also become, in a few minutes after the seizure, not merely shrunk, but singularly wrinkled, like the hands of a washerwoman after a day's hard labour. These frightful symptoms are rendered still more distressing by the shrieks and groans of the poor sufferer, often tortured by horrible spasms, which affect the fingers, the toes, the arms, or the legs,—spasms which clench the jaw, fix the walls of the abdomen in contact with the spine, or draw the trunk into singularly contorted forms. The patient thinks he obtains some relief from friction, and his cries are incessant to his attendants to "rub hard."

As the disease proceeds the countenance assumes a character peculiar to this great struggle, or the facies choleritica, the eye being deeply sunk, red, and injected; while the aqueous humour transuding its coats leaves the cornea flat and depressed as in the dead body; a broad and livid band also encircles the lower portion of the orbit; every feature, moreover, is sharp and pinched, as after a long disease; the complexion thick and muddy; the lips and tongue purple; and all these great changes have been known to take place in a few minutes.

In addition to this sad state, the vomiting is constant, the purging most incessant, and the pulse, though generally natural, sometimes rapid, yet in some cases is not to be felt, even from the first moment of the attack, either in the large superficial arteries or at the wrist. The voice also is strangely altered, its firm and manly tone has changed to a low, feeble, unnatural, and almost sepulchral sound. The urinary secretion is likewise entirely suppressed, while no bile flows into the intestines. The only organ which seems to preserve its powers is the brain; and the patient often to the last moment of his life retains the power of thinking and of expressing his thoughts distinctly, sometimes full of hope, while at others he seems indifferent to the fate which too often inevitably awaits him.

On the accession of the spasms, of the vomiting, and of the purging, the disorder is fully developed, and the crisis is at hand which in a few hours must decide the fate of the patient. The termination may be favourable or unfavourable; if unfavourable he may die with all the symptoms narrated strongly marked, or should it be favourable they may abate, and a happier prognosis be formed. Unfortunately, however, it too often happens that, although the stomach retains what is taken, and the purging appears checked, and the patient falls into a doze, yet the weakness, the entire cessation of the pulse, the coldness and lividity of the surface, and the ghastly expression of the countenance, show that a few hours must close the scene. This melancholy result occurred to Gendrin in 17 out of 20 cases, and often with so little struggle that death was only marked by the phenomenon of cadaveric contraction.

But, strange to say, death does not always terminate the singular phenomenon of the cold stage of this extraordinary disease; for in many instances after the functions of the brain have ceased, and life is apparently departed, the hand has been seen to move, the toes to bend, the jaw to become clenched, the leg to rotate, and the muscles of the thigh to quiver; and in India instances have been seen of the dead body having been drawn into an upright sitting posture, and even to make a round turn on the table on which it has been laid out. These phenomena often last for some hours, and show that the cord continues to supply a nervous power long after the brain is dead.

If the patient should happily survive the cold stage, the disease may terminate by a rapid recovery, or else may pass into the second or febrile stage. The former is the more usual course in India, the latter in Europe. The first symptom of returning health is the patient falling into a sleep of unusual soundness, during which the respiration becomes light and easy, the pulse freer, while a gentle warm perspiration bedews the whole body. This grateful pause in the disease appears to be the result of the returning powers of life, almost uninfluenced by medicine, for it often occurs where none has been given. After this balmy slumber the patient awakes refreshed, and often recovers so rapidly, that in the natives of India it almost resembles a restoration after syncope. In all the presidencies, indeed, and especially in Bengal, the recovery of the European has in general been followed by a stage of re-action, usually slight, but in some cases assuming the form of the bilious remittent or country fever, and which has occasionally terminated fatally.

In Europe, restoration after the cold stage and without febrile re-action, is by no means so frequent or so rapid as in India. Sometimes the re-action is trifling, and sleep may indeed have ensued, fæcal evacuations containing bile may have passed, the urine may again have flowed, the purging, vomiting, and spasms may have subsided, the pulse may have risen, the blueness may have disappeared, and the temperature of the body may have increased, yet in many instances this amelio-

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ration of the symptoms was only temporary, and the patients relapsed and died.

In 13 cases out of 20, however, the re-action was more considerable, and the patient, in a few hours after the subsidence of the cold stage, laboured under a severe form of fever in no degree dissimilar to, and not less fatal than, typhus. For the first few hours after the febrile re-action the tongue was white, but quickly became brown and dry, while a black sordes incrusted the teeth and lips. The eye now was deeply injected and red, the cheek pale or flushed, the pulse rapid, and the temperature of the body a little above or below the natural standard; and the patient, either delirious or comatose, lay in a state resembling the last stage of the severest continued fever of this country. This struggle usually lasted from four to eight days, when the symptoms either gradually yielded or death ensued. In a few mild cases the fever assumed an intermittent type, or sometimes a quotidian, sometimes a tertian form; all these cases usually recovered. Such is a general outline of the symptoms of this formidable disease.

The blood in cholera varies according to the stage, and that taken in the cold stage is usually of an unnaturally dark colour and thick consistency, so that it flows with difficulty from the veins, and very imperfectly separates into clot and serum. Blood also taken from the temporal artery has been found equally black and thick. Chemical analysis has shown this singular state of the blood to be partly owing to a deficiency in the quantity of serum in proportion to the clot, to a deficiency of fibrine, and to some diminution in the quantity of the usual salts. In those cases in which the urine is suppressed, urea has been detected both in the blood and in the bile. After the fever is formed the quantity of serum increases, till at length it is much more abundant in the blood than natural; and it is singular this takes place, notwithstanding the secretion of urine is re-established.

*Diagnosis.*—The phenomena of the first stage of Cholera Indica are so unlike those of any other disease that they cannot be mistaken. The second or febrile stage is similar to many of the forms of typhus fever, and is not to be distinguished from them, except by the previous history. The Cholera Indica differs from the cholera morbus of Sydenham in the lividity of the extremities, the suppression of urine, the nature of the evacuations, in the loss of the pulse, and in the greater amount of collapse.

The Cholera Indica, as seen in India, differs also from that of Europe, according to Drs. Barry and Russell, in the evacuations of the former being more profuse and ungovernable, and again from the patient being much more frequently convalescent, without passing through the febrile stage.

*Prognosis.*—The mortality from cholera in all countries is very great. Taking the whole number attacked, it is said that the number of deaths in Astrakan were as one to three; in that of Mishni Novogorod as one to two; in Moscow and Casan as three to five; and in Penza, in the country of the Don Cossacks, as two to three. In the summer of 1831 the mortality at Riga, St. Petersburg, Mittau, Limburg, and Brody, according to the Berlin Gazette, was about one-half, while at Dantzig, Elbing, and Posen, it was about two-thirds of the whole number attacked. The period of the season, however, greatly influenced the mortality; for, on the first onset, nine-tenths of all those attacked perished, then seven-eighths; and the proportion of deaths forms a gradually decreasing series of five-sixths, three-fourths, one-half, one-third, till towards the close of the season a large proportion of those attacked recovered. The uniformity of this law in every country affected with cholera, whether Europe, America, India, or China, is extremely remarkable.

The chances of recovery are much diminished in young children and in the aged; the age of greatest number of recoveries being from 15 to 20. The feeble in constitution, the sick and the convalescent, were in all cases the surest victims of cholera. But whatever the age of the party, Gendrin states he lost every case which became pulseless.

*Treatment.*—There are few diseases for the cure of which so many different remedies and modes of treatment have been employed as in cholera, and unfortunately without our discovering the antidote to this poison. In Moscow, it is said 20 different modes of treatment were practised at different hospitals, and that the proportionate number of deaths was the same in all. In the same city also, it is supposed that the mortality was not greater among those destitute of medical aid than among those who had every care and attention shown them. It may be fairly inferred, therefore, that in the severer forms of the disease, the action of this poison is so potent, as to render the constitution insensible to the influence of our most powerful remedial agents. When, however, the disease is mild, or on the decline, much may be done by obviating symptoms to promote the recovery of the patient.

The heroic remedies that have been employed in cholera, are bleeding, calomel, and opium, either separately or conjointly. With respect to bleeding, it may be stated, that in every country the patients bore bleeding badly in any stage, and that the practice in Europe was at length limited to a few leeches occasionally to the head. As to calomel that medicine was used to the greater part of an ounce in the 24 hours, but with so little success as an antidote, that many patients have been seized and died under the full influence of mercury. On the appearance of cholera in Europe, opium was administered in the doses recommended by the Indian practitioners, or to the greater part even of an ounce of laudanum, but it was soon seen that, in the cold stage, it was inefficient in controlling the vomiting or purging; that it did not allay the spasms, and, moreover, hardly produced any narcotic effect. The action of the accumulated doses of opium, however, though suspended during the cold stage, was often fully developed in the hot stage, and occasioned so much affection of the head, that most practitioners either abandoned its use, or else limited it to a mere fractional dose of that exhibited in India, or to ♏iij. to ♏xij. of tinct. of opii, or to gr. ſs. to gr. j. 6th vel 4th of solid opium.

Another heroic plan, peculiar perhaps to this country, and which was practised when the inefficiency of medicines was generally admitted, was an injection of a solution of ʒ ſs. of muriate of soda, and of ℈ iv. of sesquicarbonate of soda, in ten pints of water, of a temperature varying from 105° to 120° Fahrenheit, into the veins of the suffering patient. This solution was injected slowly, half an hour being spent in the gradual introduction of the 10 pints, and the immediate effects of this treatment were very striking. After the introduction of a few ounces, the pulse which had ceased to be felt at the wrist became perceptible, and the heat of



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the body returned. By the time three or four pints had been injected, the pulse was good, the cramps had ceased, the body that could not be heated had become warm, and instead of a cold exudation on the surface, there was a general moisture; the voice, before hoarse and almost extinct, was now natural; the hollowness of the eye, the shrunken state of the features, the leaden hue of the face and body had disappeared, the expression had become animated, the mind cheerful, the restlessness and uneasy feelings had vanished, the vertigo and noises of the ear, the sense of oppression at the precordia had given way to comfortable feelings; the thirst, however urgent before the operation, was assuaged, and the secretion of urine restored, though by no means constantly so. But these promising appearances were not lasting; the vomiting continued, the evacuations became even more profuse, and the patient soon relapsed into his former state, from which he might again be roused by a repetition of the injection; but the amendment was transient, and the fatal period not long deferred. Of 125 patients thus treated at Drummond Street Hospital, under the direction of Dr. Mackintosh, only 25 recovered,—a lamentably small proportion.

The great want of success that has attended these heroic methods, has caused every substance at any time known in the pharmacopœia to be tried as an antidote. Every metal, from arsenic to platina, was exhibited; also every vegetable and mineral acid; the various alkalies, and most of the neutral salts; phosphorus; strychnine and quina; hæmatoxylum, kino, and every known vegetable astringent; hydrocyanic acid; the entire class of narcotics; the large class of essential oils, balsams, turpentines and spices, and most tonic medicines; and when these failed, the patient has been made to respire oxygen or nitrous oxyde gas; and with a view of imparting new powers to the sinking frame, transfusion of blood has not unfrequently been performed; but all these means have been equally unsuccessful.

The failure of all these powerful means at length caused most practitioners to confine themselves to checking the diarrhœa which so frequently precedes cholera, and lays the foundation of the future attack, and subsequently to obviating symptoms. For this purpose moderate doses of opium or morphine, either alone or combined with stimulants, as the confectio opiata, or the pulvis cretæ compositus cum opio, were often sufficient. In more obstinate cases some vegetable astringent was added, as the tinct. of kino, or the decoctum hæmatoxyli, and these remedies frequently prevented the attack altogether. If, however, the disease proceeded, and the cold stage of cholera formed, the same remedies were prescribed, moderate in quantity, and often out of an effervescing draught. Heat was also now applied, and the patient wrapped up in warm blankets and hot bottles, or bags of heated sand placed around his cold and benumbed body. The warm bath was at first tried, but discontinued from the uncontrollable nature of the vomiting and purging, and the oppressive heat it produced to the patient's feelings. Mr. Dalton's vapour-bath was next used, but without benefit, and to the disappointment of the hopes which had been entertained of it. Other methods of restoring warmth were also had recourse to, as frictions with the hand, or by flesh-brush, or rubbing the body with some stimulant embrocation, compounded of garlic, capsicum, camphor, cantharides, or other powerful irritant. Mustard poultices also were often applied to the feet and abdomen, blisters with or without an addition of oil of turpentine, the part having been previously rubbed with hot sand; and in more urgent cases, the mineral acids, and even boiling water were employed for the purpose of producing instant vesication. And again, other practitioners tried to stimulate the waning powers of life by galvanism, acupunctuation of the heart, issues, setons, moxas, actual cautery along the spine, and lastly, by small pieces of linen dipped in alcohol, and distributed over the body, and then set fire to.

In a few instances these efforts were rewarded with success, re-action and the second or febrile stage formed. It was at this period that some physicians thought that calomel should be exhibited in moderate doses, for the purpose of producing a flow of bile into the intestines, and of emulging the gall-bladder and ducts, as well as of restoring the other suppressed secretions. The indications, however, more generally followed, were to treat the case as we should a similar state of typhus, namely, to moderate the affections of the bowels by mild opiates, by enemata, and by sinapisms to the abdomen; also to relieve the head by leeches and cold lotions, and subsequently, as the tongue became brown, to support the patient with wine, sago, strong broths, and a generally cordial treatment.

*Dietetic and Preventative Treatment.*—It is plain, from the severe derangement of the alimentary canal, that mucilaginous drinks and light broths, either alone or combined with brandy, will be proper in the first stage of the disease. In general these drinks were given warm, but the patient had often a craving for iced cold drinks, and no inconvenience has resulted even when he has drank freely of them. In the second stage, the diet was a milk diet, with strong broths, but wine was seldom beneficial, or only so in very small quantities.

The preventative rules were to avoid everything that could occasion indigestion; for in every country there were numerous instances of cholera having immediately followed eating ascescent fruits, or uncooked vegetables. In Calcutta, eating shell or the table fish caught in the Ganges has often led to the same consequences. Acts of intemperance or debauchery were equally fatal. In India it is an axiom to avoid the great heats of the day, and also the damps of the night air. Again, on a march to avoid, as far as possible, encamping in infected districts, or on the banks of rivers. The greater question, however, which a consideration of the preventive treatment involves, is, whether cholera is or is not contagious, and consequently whether any precaution is necessary in our intercourse with the sick.

The great argument, which is urged in favour of the contagious nature of cholera, is that, originating in India, it has spread east and west, extending along the high roads and banks of rivers, from city to city; and also that in a very few instances the medical and other attendants have suffered in a larger proportion than the community generally, and consequently it is inferred that the disease is propagated by miasmata generated by the patient's person. On the contrary, it is contended that cholera is not contagious, because that disease still rages in India with its fullest force, and yet does not spread, although the communications with that country are far more frequent and rapid than at any former period. Again, that the progress of cholera has been in no degree dissimilar to that of other epidemic diseases not generally considered contagious.

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And lastly, that the instances of medical officers and other attendants on the sick not suffering in a greater proportion than the rest of the population, are numerous, and far outweigh the few cases which can be adduced to the contrary. It will only be necessary to add a few examples of the immunity of the attendants generally on the sick to place this argument in its proper light.

Mr. Jameson states, that in Bengal the general voice of the inhabitants at large is uniform against the disease being contagious or conveyed from person to person. He adds also, of 250 officers, comprising the medical staff in Bengal, all but one are non-contagionists; and that out of the whole list only three of these gentlemen were known to have been attacked with cholera during the three years it most severely raged, or from 1817 to 1820. On the Bombay side also the reports equally corroborate the general exemption of the medical officers and attendants on the sick. Thus Dr. Taylor affirms, of 44 assistants employed under him only three were seized with cholera.

It has been thought that the disease, though not contagious in India, where the Hindoo lives "sub dio," and is, from his religion, cleanly to excess, might still be contagious in Europe, where it acquired a new property of a febrile stage, and where the habits of the people are less cleanly, and indeed entirely different, from those of the natives of India. But the evidence of the non-contagious nature of cholera is as positive in Europe as in India.

Drs. Russell and Barry, in their communications with the British government, state, that 25 physicians at St. Petersburg held a consultation whether the cholera was or was not contagious, when 21 declared it to be non-contagious. Chambert, of the Warsaw commission, states, that of 100 physicians, English and German, about the sick in Warsaw, none suffered from cholera.

The number of practitioners in Paris is estimated at 1800, yet not more than 25 to 30 laboured under this disease, and of these not more than 15 or 16 died. Again, the wards of the Hôtel Dieu, assigned for the reception of the cholera patients, were filled, still no case was proved to have occurred from infection among the 12 physicians, the 100 pupils, or the many hundreds of medical men that came from all quarters to see the disease. The nuns and the nurses escaped also with an inconsiderable mortality. In England, in Gibraltar, and in the Canadas, the experience of the profession was to the same effect; and if we add to this, that many hundred bodies were dissected, that some physicians inoculated themselves with the blood drawn from the cholera patient, and also tasted the matter vomited; have lain also in the wards of the cholera hospitals for nights together, rubbed, been in the closest contact with the sick, and yet have not fallen in any greater proportion than the population generally—the conclusion seems forced that cholera is an *epidemic*, and not a contagious disease.

### Of the Poison of Influenza.

Influenza is a catarrhal affection, generally accompanied by fever and cough, sometimes with sore throat, and often going off with an affection of the bowels.

This class of affections was known to Hippocrates, and is mentioned in his aphorisms, his prognostics, as well as in other parts of his works; but this physician, as well as the ancients generally, considered it as having merely a local origin, as being endemic in different towns and districts of Greece or Italy, and as being caused by the vicissitudes of the weather. Towards the close of the XIIth and XIIIth centuries, however, it was observed that catarrh was not only endemic in particular districts, but that it occasionally spread over large portions of country, while still later, or in the year 1557, it was found to prevail epidemically, not only over the whole of Europe, but even over the whole of the northern hemisphere, beginning in Asia and proceeding westward till it terminated in America. In the XVIIIth century a new law of its progression was observed, as that having advanced westward till it reached the Elbe, it passed over the intermediate countries and reached England, where the stream broke into two branches: the one crossing the Atlantic to America, while the other retrograded south-east through France, Spain, and Italy, till it was lost in the Mediterranean,—a course similar to that described by cholera.

*Remote Cause.*—The influenza has occasionally originated as far eastward as India, but more commonly it has broken out in the north of Europe, as Moscow, Warsaw, or Dresden; and consequently there must be many primary foci or centres of this poison. It seems probable that, like the poison of Cholera Indica, its spread may be limited to a small number of these primary foci; for we find, in every volume of the Calcutta Transactions, accounts of some catarrhal fever spreading for a season along the banks of some principal river, and then subsiding; so that it is evidently only occasionally and at long intervals *erratic*, as in 1729, 1743, 1775, 1782, 1831, 1833, and 1837. The influenza, therefore, is both endemic and epidemic; and, in the latter case, we find it, at least in Europe, spreading from east to west, prevailing in the depths of winter as well as the heights of summer, lasting nearly the same space of time in the different towns and cities it attacks, or from four to six weeks, affecting contiguous places in different degrees and at different times—circumstances so remarkable, that it seems impossible to explain them, except by supposing the existence of a poison generated beneath the crust of the earth, and beyond the reach of atmospheric influences: an hypothesis which assimilates its origin to that of Cholera Indica.

On looking to the habits of this poison it is probable that its actions are not limited to men; for in most years, when influenza has been epidemic, a similar disease has been epizootic.

*Predisposing Causes.*—The attack of influenza is for the most part so universal that large portions of the population of every country in which it has prevailed, without respect to age, sex, or condition, have been commonly infected. In general, however, women, from being less exposed to the weather, have suffered in a smaller proportion than men, and children less than either. In all of these epidemics the aged, however, suffer greatly. The calculation of Dr. Heberden for the year 1837 is—of persons between 30 and 40, 412 died; of persons between 50 and 60, 500 died; while of persons between 70 and 80, 563 died, an enormously increasing ratio. In the same year also the mortality at Salpetrière, where the inhabitants are chiefly the aged poor, was increased one-third over former seasons.

It has been remarked, in the several influenze, that the low parts of the towns have been more generally and more severely affected than the higher and more healthy districts.

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*Susceptibility exhausted.*—Few persons suffer more than one attack of influenza in the same season, although many relapse; but one attack of this poison in no degree protects the constitution from a second in another season.

*Co-exists.*—The influenza has often co-existed with measles, scarlatina, syphilis, and probably with every other disease produced by any other morbid poison.

*Modes of Absorption.*—This poison probably follows the laws of most other morbid poisons, and is absorbed by the mucous tissues, and infects the blood. The argument for the latter assumption is, that influenza has been greatly fatal to pregnant women. Majendie, speaking of this law, says, "I *believe* it, although I dare not affirm it."

*Period of Latency.*—It is extremely difficult to determine the period of latency of an epidemic disease. If, however, we suppose the poison to have a land origin, there are instances of persons being seized within 24 hours after their landing from a voyage from a foreign country. In other cases, however, the period has appeared to vary from 10 to 20 days.

*Pathology.*—The theory of this disease is, that a poison is absorbed and infects the blood, when, after a given period of latency, it produces disordered functions of the great nervous centres, ensuing great general depression, together with slight or severe remittent fever. The specific actions of this poison are on the mucous membrane of the eyes, of the nose, and of the bronchi, causing common catarrh. In a smaller number of cases, on the mucous membrane of the fauces, causing sore throat, and in a still smaller ratio on the substance of the lungs and on the pleura, causing inflammation of those organs. In most instances the disorder terminates in diarrhœa by an ultimate action of the poison on the mucous membrane of the intestinal canal. These different pathological phenomena vary in frequency and complexity in different seasons.

In most cases, when the poison is of sufficient intensity to produce fever, the type is remittent, with exacerbations in the evening. Its usual duration is two, three, or four days, when it terminates in an abundant sweat, and which not unfrequently leaves great debility behind it.

At the same time, however, with the fever, or else preceding or succeeding it, the patient has in general been seized with a slight inflammation of the ocular and nasal membranes, followed by coryza, or the serous discharge of a common cold or catarrh; and this inflammation generally affects the larynx and trachea, while either are attacked by sore throat or pneumonia.

The proportionate numbers of those attacked with pneumonia cannot perhaps be determined, for the hospitals admit only the worst cases. Thus, out of 125 male patients suffering from influenza, and admitted into the Hôtel Dieu, between the 15th January and 1st March 1837, 33 laboured under pneumonia—an enormous proportion. The women appeared to suffer in a less proportion from this inflammation, for out of 58 female patients 7 only had pneumonia.

The pneumonia occupied most commonly the middle and lower lobes, and only rarely the summits of the lungs: out of 40 cases observed by M. Landan the inflammation occupied 21 times both lungs, 11 times the right lung, and 8 times the left. The forms of pneumonia are principally serous inflammation and red hepatization, the latter occasionally interspersed with a few points of pus. Majendie, in demonstrating the nature of "la grippe" to his pupils was enabled to show them specimens of both those states.

The bronchial membrane, when examined, was in general found red, and covered with the secretions usual in bronchitis. The appearance of the sore throat was that of a broad dusky-red band extending over the fauces, uvula, and tonsils. The uvula was elongated; but the tonsils were rarely swollen, and still less frequently ulcerated.

*Symptoms.*—The symptoms of influenza often form themselves into different groups, giving rise to many varieties. Thus the catarrh often existed without the fever, and, in a smaller number of cases, the fever without the catarrh. The angina was frequently the most prominent symptom, while in other instances the bronchial affection alone harassed the patient.

Whichever of the forms prevailed the disease usually began with shivering, general soreness, headache, and pains in the limbs; and these symptoms were frequently accompanied by fever, slightly increased towards evening. The patients were usually seen about the third or fourth day, and they now complained of cough, tightness of the chest, of pain in the epigastrium, and also of dyspnœa. The face was likewise flushed, the alæ of the nose red, the lip vesiculated, the eyes streaming with coryza, and the voice altered as in a common cold. The tongue was moist, or coated with a yellow mucus, the skin open and without morbid heat, the pulse little augmented in frequency. But notwithstanding each of the particular symptoms were mild, there was a languor, debility, and dejection of spirits far beyond what might have been expected, and almost exceeding that of common fever, and which was in many instances long in subsiding.

In mild cases these symptoms constituted the whole disease, and the patients recovered about the eighth or tenth day, after suffering for a few hours from sharp diarrhœa. In many instances, however, the patient, in addition, suffered from mild or severe sore throat, or a cough came on and continued for many weeks. In a few cases the symptoms were of a more aggravated character, the fever being more marked, the pulse accelerated, the skin hotter, and the cough more troublesome; and this has often been followed by inflammation of the lungs.

Inflammation of the substance of the lungs seldom occurred till the second or third day, and more commonly not till the fifth or sixth day; and although generally, was not always preceded by shivering, or even by bronchitis. The pneumonia in some years has been characterized by well-marked symptoms, as pain in the side, dyspnœa, and by purulent or sanguineous expectoration, so that nobody could mistake it; but in general the pneumonia has been adynamic in character, and presented a striking contrast to the usual symptoms, there being scarcely any local pain, the pulse, ordinarily so large and full, has been slow and small, and though sometimes counted between 80 and 90, has ranged more commonly from 60 to 70. The face also, instead of being full and red, has been sharp and pale, the lips blue, and the extremities cold. The patients also, who generally preserve a good deal of power in the ordinary forms of pneumonia, were now so weak that they were obliged to be supported while auscultated; and even this mode of exploring the chest did not afford the usual indications, for crepitation was rare, and the

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respiratory murmur heard, except in a few points, all over the chest, while there was little or no bronchophony. The expectoration likewise had not the characters observed in simple pneumonia, for instead of being purulent and mixed with blood, it was thin, transparent, and viscid, and, if fever accompanied it, it was usually of an adynamic character, marked by a brown tongue, an accelerated pulse, and occasionally by delirium.

The appearances of the sore throat have been already mentioned, and its character was generally asthenic, and only in a few instances of a sthenic character.

*Diagnosis.*—It is extremely difficult to say in what influenza differs from a common cold, either in its symptoms or in its consequences. It seems probable, however, that they both depend on the action of the same poison, varying perhaps in intensity and general diffusion. In the year 1783 it was conceived that the debility which always accompanies the influenza, and the rapid manner in which it was formed, give the most obvious distinctions, and perhaps no better diagnosis can be found.

*Prognosis.*—Children and persons under 40 died in a very small proportion, unless in a previous state of ill-health. The mortality, however, among the aged has in every country been great from this disease. It has been remarked, also, that the disease, if not fatal in itself, left the patient, of whatever age, often greatly debilitated in body and depressed in spirits, and that those with tender lungs frequently fell into phthisis, or continued to cough for several months afterwards, so that a complete recovery was often long and tedious.

*Treatment.*—As a general rule the great majority of cases in these epidemics have scarcely required any medical treatment. In that of 1782 it was observed that "many indeed were so slightly indisposed as to require little or no medicine; nothing more was wanted to their cure than to abstain for two or three days from animal food and fermented liquors, and to use some soft diluted tepid drink. A lenient purgative at the beginning of the disease was useful in moderating the fever, and nature seemed to point out the repetition of it afterwards when there was pain in the stomach and bowels and a tendency to diarrhœa. The same was observed in 1762. Nothing likewise was observed so successfully to mitigate the cough as to open the bowels with a gentle purge, and afterwards to give a gentle opiate at night."* In the year 1837 it was also remarked, as long as the symptoms were limited to cough, hoarseness, headache, or other pains moderate in degree, that the patients all recovered by putting them on a low diet, by attending to their bowels, and confining them for a few days to the house; and if more was attempted it was quickly found that the disease ran a course scarcely influenced by medicine. A smaller number, however, required medical attendance, either from the severity of the bronchitis, the occurrence of pneumonia, of angina, of the disordered state of the bowels, or more often from the debility induced by the disorder.

In general when the bronchitis was severe, but the substance of the lung as yet unaffected, leeches to the chest, or cupping, or moderate bleeding were borne extremely well, and the patient relieved; while in the aged, blisters to the chest, followed by a series of linseed poultices, were often of essential service; and this treatment, together with neutral salts, opiates, and diaphoretics, in general effected the cure. In all the great influenze, however, it has been remarked that the whole class of expectorants were either useless or uncertain in their action.

In pneumonia it has been found, that although a few persons bore the loss of a considerable amount of blood, yet in general that blood taken beyond a very limited quantity, as 12 to 16 ounces, either did not relieve the complaint, or was actually prejudicial. It is in this form of pneumonia that large doses of the antimonium potassio tartarizatum have been found so advantageous. Indeed it seems distinctly proved that this form of pneumonia will not bear that powerful antiphlogistic treatment which is necessary when it arises from general causes and is of a more sthenic character.

When the patient was affected with angina, it yielded readily to the usual law of treatment of that affection, or to small bleedings when the tonsils were swollen, and to small quantities of wine when the tonsils presented little or no increase of size. The derangement of the bowels also readily yielded to the usual laws of their treatment, or to purgative medicines when constipated, and when affected by diarrhœa and accompanied by pain, to mild purgatives and opiates, or else to the pulvis cretæ compositus c. opio.

When the fever and other immediately alarming symptoms of the influenza had ceased, there frequently remained a teazing cough, and the convalescents in general complained of languor, want of appetite, and that their sleep was broken and unrefreshing. For removing these complaints, change of air and riding on horseback were most effectual, and to some they were absolutely necessary; and in addition to these, mild tonics, or else the natural chalybeate waters drank at the spas were of singular service.

*Dietetic and Preventative Treatment.*—In slight cases it was sufficient to limit the patient to white fish and puddings, and in the severer forms to slops and light puddings. The night air was universally prejudicial. It does not appear that any precautionary treatment was of service in preventing the spread of this disease among the attendants on the sick; for when four-fifths of the population were labouring under the disease, it can hardly be considered as having spread by contagion.

We must here conclude this short elementary account of the wide-spreading pestilence, and of the many other direful forms and shapes of disease, and of our imperfect means of curing or assuaging them. Death, however, produces life, and we may add—

"Many are the ways that lead
To his grim cave, all dismal; yet to sense
More terrible at the entrance than within."

* *Med. Trans.* vol. ii. p. 71.

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# INDEX TO THE ELEMENTS OF MEDICINE.

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MEDICINE.

- Diseases arising from General Causes.
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## MISCELLANEOUS INDEX.



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# SURGERY.



General remarks on the Division between Surgery and Medicine.

SURGERY, or CHIRURGERY (χειρ, the hand, εργον, a work), a name originally given to that very limited department of the healing art which undertakes the treatment of external injury or disease by manual interference, either with or without the aid of instruments; thus differing from the practice of physic, properly so called, which has for its object the cure of internal diseases by the administration of drugs, the regulation of the diet, or other measures of a general kind. But in the present day the word Surgery implies much more than seems originally to have been intended by it, inasmuch as it has been found impossible, consistently with the safety of the sick, to carry out in practice the distinction above mentioned. At one period of the history of civilized nations a clear and definite line was actually drawn, by which the surgeon was strictly limited to the performance of operations, the application of bandages, ointments, &c., while the physicians, assuming the air of superior learning, deemed it derogatory to their profession to intermeddle with such things, though they claimed exclusive authority in directing their employment. The most varied and fatal experience attested the erroneousness of the principle involved in this artificial disjunction of the hand from the head. The surgeons were ignorant of all that knowledge which alone could make their operations safe and effectual: they either followed implicitly the orders of their superiors, or travelled the country as mountebanks and impostors, impudently undertaking the most serious and responsible duties without the slightest acquaintance with first principles; while the physicians were disabled from the power of giving correct advice by the total want of that practical experience which is essential to the education of the judgment.

The more deeply we carry our researches into the nature of Life and vital processes, the nearer do we approach towards the apprehension of this fundamental truth—that all the reparative as well as destructive actions that occur in living bodies are but aberrant forms of natural actions, and capable of being understood only through the medium of these latter. Hence Physiology becomes the basis of Pathology, as Pathology is the foundation of Medicine. In modern times, and especially of late years, it has been universally acknowledged that the surgeon, as well as the physician, must be thoroughly conversant in these branches of science ere he can have any pretensions to practise his profession with honour and success.

Some persons suppose, on grounds like these, that no distinction should be drawn between the physician and surgeon, but that both should bear the same title and perform the same duties. But reason, as well as experience, demonstrates that the numerous and complex details connected with the practice of each department render necessary, for the attainment of adequate skill in either, a division of labour. The whole science and art of medicine together seem too vast to be fully comprehended in the scope of a single life; and, although it must be conceded that the great mass of the profession is concerned at once in both departments, yet this is to be attributed solely to those circumstances of society which render it a matter of necessity rather than of choice. In all large communities, where wealth and numbers afford the stimulus and opportunity, and where talent is ever ready to exert itself, there will always be found persons applying themselves in a more peculiar manner to the study of one or other of the two great departments already spoken of, and even to minor subdivisions of these. Such persons, as a body, have been liberally brought up and furnished with enlarged views of those sciences which lie at the foundation of medicine; and their dedication to special branches of the healing art is most admirably calculated to extend its blessings, not merely by their personal ministration to the sick, but in particular by the improvements in medical knowledge accruing from their study and experience. It is in fact this class, with few exceptions, that has furnished by far the greater number of writers on medical subjects, and by which the most considerable advances in knowledge have been achieved. There can be no doubt that the separation of physic and surgery has been in this way productive of the very best results to both, and that nothing could be conceived more likely to impede the progress of knowledge, and to interfere with the application of its benefits, than a complete amalgamation of these twin professions. And yet it must be confessed that, partly from the bias of education and a current system, and partly from the natural proneness of mankind to undervalue or disregard what does not immediately concern them, the breach between medicine and surgery has been often widened, and sometimes their essential connexion almost altogether lost sight of by practical writers; and the tendency has been to introduce into medical literature an arbitrary division, corresponding with that followed in practice, and one that has to some extent injuriously obstructed the growth and reception of general principles and views.

In the discussion of these important subjects in the present work, it would be inconvenient not to adopt the division ordinarily followed; but, to avoid repetition, the Article MEDICINE is intended to embrace the principal part of the general history of morbid actions, or *general pathology*, as well as the particular account of the diseases usually termed *medical*. In the following pages we shall first introduce a sketch of the history of surgery, and then, under separate heads, treat as plainly and succinctly as we are able of some of the principal injuries and diseases which custom has assigned to the care of the surgeon, referring now, once for all, to the treatise on Medicine for much of that information which is commonly found in systematic works on Surgery.

History of Surgery.

The early history of surgery is necessarily connected



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Surgery. History.

with and inseparable from that of medicine, since both were originally practised indiscriminately by the same individuals, and it was at a comparatively recent period that a complete separation was made. Even without the authority of history for the fact, there can be little doubt that surgery, or chirurgery, in the literal acceptation of the word, is by far the most ancient department of the healing art. From the time of the fall mankind must have been subject to various casualties and injuries arising from mechanical violence; such injuries they would soon seek to alleviate and repair by means which the commonest observation and the simplest process of reasoning would dictate; experience, too, would early teach them something of the reparative powers of nature, and how much might be done by judiciously acting in aid of those powers. Many years must have passed away before necessity called into existence a more elaborate art of healing than this. But in process of time, as mankind departed from the natural simplicity of their primitive mode of life, and as habits of luxury and indolence crept over the world, when the once open plain became covered with the crowded city, with its attendant miseries and malignant influences,—in proportion as these changes occurred, the robust health and longevity enjoyed by the early inhabitants of the earth gave place to the effeminacy and the innumerable ills which afflict their degenerate and comparatively short-lived descendants. With the increase of disease and sickness the means adopted for relieving them have become more numerous and varied; until in these later days, with all the resources of our art, we are unable to bring many even to the very confines of old age.

Egyptians.

Some writers who have investigated the point assign to the ancient Egyptians the merit of having first successfully cultivated the art of medicine. It has even been said that in practice they divided it into distinct branches. This would at first view indicate a considerable degree of advancement in the art; but other circumstances seem contradictory to such an opinion. The medical practice was entirely confined to the priesthood, and must have been based on the grossest superstition: it consisted for the most part in magical incantations and other ceremonies, the efficacy of which as remedial measures must be wholly attributable to any influence they may have exerted upon the imagination. The evidence which we possess of their entire ignorance of the very elements of anatomy and physiology is a sufficient proof that their knowledge of surgery was extremely limited.

Jews.

In the writings of Moses there are numerous allusions to the practice of medicine among the Jews, especially with reference to the cure of leprosy. The medical treatment, which was confined to the priests, consisted in the adoption of means for the promotion of cleanliness and the prevention of contagion.

Hindoos.

The Hindoos appear to have possessed at a very early period a certain knowledge of medicine. We are told that there existed amongst them a law by which any one who discovered a poison, at the same time making known the antidote, was richly rewarded; but if he made known the poison without the antidote, he was punished with death. The account which we have given of the state of medicine among the ancient Egyptians and other contemporary nations, is as full as the scanty records which remain upon the subject permit. We next proceed to trace its progress in Greece, where it first began to assume the rank of a science.

Chiron the Centaur.

Chiron the Centaur is said to have introduced the art of medicine among the Greeks. We learn that he was a native of Thessaly, and distinguished for his knowledge of the arts of life; he was frequently seen on horseback, and hence arose the fabulous account of his compound form. We are told that he instructed in the art of medicine the heroes who were engaged at the siege of Troy.

Æsculapius and his Descendants.

But the most distinguished among the disciples of Chiron was Æsculapius, a native of Epidaurus. His reputation as a successful practitioner must have been very considerable, if we may credit the account of his death, which is said to have been caused by the anger of Pluto, in consequence of the number of individuals whom he had rescued from the grave. So highly was he esteemed among his countrymen, that after his death divine honours were paid him. He was designated the God of Physic, and temples were erected to him in various parts of Greece. The two sons of Æsculapius, Machaon and Podalirius, accompanied the Greeks to the Trojan war, and there acquired a great reputation in the treatment of wounds. Internal diseases, which were attributed to the anger of the gods, were altogether neglected, or attempts were made to remove them by the practice of charms and incantations.

The Asclepiades.

During a long period of several centuries after the Trojan war, medicine made but little progress, and the records which we possess upon the subject are scanty and unsatisfactory. The practice appears to have been exclusively confined to the Asclepiades, who were the reputed descendants of Æsculapius, and the guardians or priests of the temples erected in his honour. The treatment adopted by them consisted chiefly in the performance of certain rites and ceremonies; and the influence which they acquired over the minds of their patients was, doubtless, made use of to their own advantage. The temples dedicated to Æsculapius were converted, to a certain extent, into schools of medicine. The most celebrated were those of Cos, Cnidos, and Rhodes; the first of these is noted as having been the school of Hippocrates.

Pythagoras.

Pythagoras, who lived about six hundred years before the Christian æra, has the merit of being the first who brought the principles of philosophy to bear upon the study of medicine. The introduction of a more correct mode of reasoning had the effect of weakening the strong-holds of mystery and superstition, and from this time medicine may be said to have assumed, in some degree at least, the dignity of a science.

Democritus.

Amongst the most illustrious of the followers of Pythagoras is Democritus. He has the credit of having paid particular attention to the study of comparative anatomy; and there is some reason for believing that he even went so far as to dissect the human subject, in spite of the prejudices then existing against such a practice.

Hippocrates.

The individual who contributed more, perhaps, to the advancement of both medicine and surgery than any other single individual either of his own or of any other age, is Hippocrates. Notwithstanding his great and deserved celebrity, a celebrity so great as to obtain for him among his contemporaries and successors the name of the Father of Physic, we have no very precise knowledge of his personal history. The history of his opinions is, however, preserved and handed down to us in his

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Surgery. Hippocrates.

numerous and much valued writings. He lived about 400 years before the Christian æra; he was educated among the Asclepiades at the temple of Cos; he was a pupil of Herodicus, and is supposed to have been a descendant, in the eighteenth degree, from Æsculapius. He was not content to follow the philosophical mysticisms of his predecessors, but, taking experience as his guide, he made a careful observation of nature, and after collecting a number of facts, he sought, in the spirit of true philosophy, to deduce the general laws by which those facts might be explained. So accurate an observer was he, that many of his descriptions of disease are recognized, even at the present day, as models of accuracy and precision. His knowledge of osteology was evidently very accurate, but, with this exception, his anatomical acquirements were scanty, and his ideas in many cases singularly erroneous. This is readily explained, when we consider the prejudices then existing against human dissections, and the necessity thereby induced of trusting to an examination of the bodies of the lower animals. He did not distinguish between the veins and the arteries, but called them by the common name of φλέψ; hence the assertion, which has been sometimes made, that he in any way anticipated the discovery of Harvey, is undeserving a moment's consideration. His knowledge of the nature and functions of the nervous system was likewise exceedingly limited. In the writings of Hippocrates we meet with the first traces of physiological science; and some of his ideas upon this subject are remarkably correct and profound. We are indebted to him for the hypothesis of a principle which he calls the vital principle, which influences all parts of the body, superintending and directing its motions, and which, as it were, by a kind of intelligence promotes all those actions which are beneficial, at the same time opposing those which have an injurious tendency. Although it is upon the improvements which he effected in the practice of medicine, that is chiefly founded the great reputation of Hippocrates, yet he was evidently skilled, to a considerable extent, in the art of surgery. He is said to have been the inventor of the art of bandaging. His remarks on the effects of wounds display much accurate observation, and the treatment prescribed is correct and rational. In his treatise on wounds of the head, he points out, with much care, the circumstances requiring the use of the trepan; he appears, however, to have been somewhat reckless in the use of this instrument, and to have adopted it in some cases where the surgeon of the present day would consider it more prudent to refrain. In his directions for the treatment of fractures he has pointed out the period at which firm union ordinarily occurs; not forgetting to mention the influence which age, sex, and other circumstances may exert in hastening or retarding the formation of callus. He made use of complicated machines in reducing the dislocations of large joints; the displacements of the smaller joints he treated with comparative simplicity. He tapped the chest in cases of hydrothorax, after practising percussion to ascertain the presence of the liquid. He was evidently acquainted with tetanus, observing that in many cases small wounds in tendinous parts, such as the toes and fingers, give rise to violent and fatal convulsions. His knowledge of spontaneous gangrene is evinced by the observation that "black spots on the feet frequently increase to extensive gangrene and incurable mortifications."

Surgery. Diocles.

During a considerable interval which elapsed after the death of Hippocrates, we meet with the names of but few individuals who contributed, in any great degree, to the advancement of medicine. His successors were, for a long time, content to follow the course of their great master, and to yield unqualified assent to all his doctrines. The only remaining names amongst the Asclepiades that are in any considerable degree distinguished are Diocles of Carystus, and Praxagoras of Cos. The former of these obtained great celebrity for his learning and skill. He paid more attention to the study of anatomy than any of his predecessors had done; but his knowledge of this subject appears to have been very limited, and to have been chiefly derived from an examination of brutes. His idea of the vascular system was a somewhat nearer approach to the truth than any opinion entertained before him. His notion of the nature of the respiratory process was, that it served to moderate the internal heat of the body. In his pathology and practice he differed little from Hippocrates. He paid particular attention to the symptoms of diseases, and especially to those derived from an examination of the urine. In the department of surgery, he was the inventor of an instrument for the extraction of darts.

Praxagoras.

Praxagoras of Cos was another of the Asclepiades; he paid particular attention to the study of anatomy: he first distinguished the arteries from the veins, and to him is due the merit of having first observed that the pulse may be taken as an important index of the state of the vital powers. He practised several surgical operations; he had frequent recourse to blood-letting, especially for the purpose of arresting hæmorrhage; on the whole, his surgical practice appears to have been characterized by boldness rather than by prudence; we are told that he excised portions of the soft palate in cases of quinsy; and in cases of colic he opened the abdominal cavity for the purpose of restoring the intestines to their natural condition. Aristotle deserves honourable mention here, on account of the great advances which he made in the study of Anatomy and Natural History. He was the first who pointed out the origin of all the blood-vessels in the heart, and he gave the name of aorta to the largest artery in the body. His knowledge of anatomy, however, does not appear to have been derived from human dissections.

Aristotle.

School of Alexandria.

After the death of Alexander, and the dismemberment of the Macedonian empire, Alexandria became the chief abode of learning. It was about 300 years before the Christian æra that Ptolemy Soter laid the foundation of the celebrated Alexandrian library, and of the school of philosophy. Here all the sciences were assiduously cultivated; and the students of medicine enjoyed many privileges which were denied their predecessors. The chief of these was the opportunity of dissecting the human subject, the bodies of criminals being given up for that purpose. The most celebrated anatomists of that period were Theophilus and Erasistratus. The descriptions which they gave had the peculiar advantage of being taken from nature, instead of being a mere repetition of the errors of those who had preceded them. They made many valuable discoveries in anatomy and physiology; of these, one of the most important is that of the functions of the nervous system. Theophilus was the first who regarded the nerves as the organs of sensation, although he continued to call the nerves and tendons by one

Theophilus.

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Surgery. Erasistratus.

name. He traced the cerebral nerves to their origin, and described the pia mater; he also discovered the lacteal vessels. The discoveries of Erasistratus were not less important. But, although they made great advances in the study of anatomy, they still retained many curiously erroneous notions of physiology. They believed that the object of respiration is to fill the arteries with the "vital air;" they supposed the air to pass from the lungs through the pulmonary veins to the heart, and thence into the arteries. Erasistratus practised surgery with such a degree of boldness, that in cases of abscess in the liver or spleen, he did not hesitate to open the abdomen to apply his remedies immediately to the diseased parts. On the contrary, he was unwilling to puncture the abdomen in cases of ascites, knowing the disease depends on organic changes which could not be removed, although temporary relief might be given, by such an operation. It is important to bear in mind that about this time, that is, soon after the establishment of the Alexandrian school, the profession of medicine was divided into the three departments of dietetics, pharmacy, and surgery, each division being exercised by separate individuals. The surgeons of Alexandria appear to have attained to a considerable degree of dexterity in many of the most important operations; of these the one most deserving of attention is that for stone in the bladder, to which, it is said, some individuals devoted themselves exclusively, and were denominated lithotomists in consequence. It was always done by them with the apparatus minor, as described by Celsus. A surgeon, named Ammonius, about this time invented an instrument for crushing a stone in the bladder, when without such a proceeding the size of the stone was too great to admit of extraction. This fact, for which we have the authority of Celsus, is a sufficient proof that the idea of lithotrity is by no means a modern one.

The Romans.

For a period of some centuries Alexandria produced a succession of learned men in medicine and in various other sciences. During this time Rome was beginning to extend her empire over Europe; but her people were too much occupied with warlike deeds to pay much attention to the sciences, and medicine, among the rest, was for a long time entirely neglected. Not only was the study of medicine disregarded by the Romans, but its professors were banished, and the priests, once more, undertook the cure of diseases by the performance of superstitious ceremonies and the practice of charms and incantations. After some time, however, medicine again began to be looked upon with respect, and a Greek named Archagathus established himself in Rome, and acquired a considerable reputation. But he unfortunately incurred the popular displeasure, on account of his surgical practice, which was thought unnecessarily severe and cruel; and he was in consequence banished from Rome. Some time after this, Asclepiades of Bithynia acquired great popularity as a practitioner, for which he appears to have been indebted to the strict attention which he always paid to the comfort of his patients, his regard for their prejudices, and his indulgence of their inclinations. In addition, however, to the knowledge of human nature, and of human frailties, which this method of practice would show him to be possessed of, he appears to have been an accurate observer of disease. It is said that we are indebted to him for having first divided diseases into the two classes of acute and chronic,—a division which the observation of subsequent ages has shown to have a foundation in nature.

Celsus.

The name of the first native Roman practitioner that has been handed down to us is that of Aulus Cornelius Celsus. It is curious that the history of an individual of such great and deserved eminence should be involved in considerable obscurity. We are uncertain as to his age and origin; and even the nature of his profession is doubtful. His work, *De Re Medicâ*, is, however, sufficient proof of his having devoted much time and attention to the study of disease and its mode of cure. He defends the study of anatomy against the empirics, who totally disregarded it. The description which he gives of certain parts of the back proves that he must have dissected the human subject, but his knowledge of some other parts appears to have been derived from a study of the organization of the lower animals. He does not always distinguish the arteries from the veins: he has no very exact idea of the nerves, for he sometimes gives this name to tendons, and even to muscles. Many of his surgical precepts may be advantageously followed, even at the present day. His method of operating for stone has been strongly advocated by Heister as being especially applicable to children. His rules for the application of the trepan are deserving of the highest praise. He gives full directions for the treatment of fractures and dislocations. He describes the operation for cataract by depression. He mentions several varieties of hernia, and gives directions for their reduction. He speaks of the application of a ligature to bleeding vessels, when pressure and other means have failed; but he probably was ignorant of the great value of this practice, since the suggestion appears to have been entirely disregarded by his contemporaries. These examples of the practice of Celsus will suffice to show that in his day surgery had attained to a considerable degree of perfection.

Heliodorus.

Heliodorus was a celebrated surgeon who lived during the reign of the emperor Trajan. He made some excellent observations on wounds of the head and the use of the trephine. His rules for the performance and subsequent treatment of amputations differ little from those which are followed in the present day. About the same time lived Antyllus, who contributed much to the advancement of surgery, but, unfortunately, most of his writings have been lost. He recommends the performance of arteriotomy in some diseases, and directs that the vessel should be completely divided if the hæmorrhage cannot otherwise be restrained. He speaks of the operation for cataract by extraction, but recommends its performance only in cases where the cataract is small. He recommends and gives precise directions for the performance of tracheotomy in cases of threatened suffocation from diseases about the throat. He effected the radical cure of hydrocele by incisions into the tunica vaginalis.

Antyllus.

Galen.

One of the most distinguished of the ancient practitioners of medicine was Claudius Galenus. He was born at Pergamus, in the 131st year of the Christian era. He had the advantage of an extended and liberal education: he studied philosophy in the different schools which were in most repute, and subsequently went to Alexandria for the purpose of completing his medical education. At the age of 28 years he returned to his native country, and soon afterwards went to reside at Rome. Here he became a public teacher, as well as a practitioner, and the reputation which he acquired

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Surgery. Galen.

excited so much jealousy and hatred towards him that he was induced to leave Rome. He afterwards returned, at the request of the emperor Aurelius, and remained there until his death, which occurred about A.D. 200. The numerous writings of Galen sufficiently evince the brilliancy of his talents and the extent of his acquirements. The opportunities of studying anatomy appear to have been at that time very limited. He considers himself fortunate in having had the advantage of studying two skeletons which were preserved at Alexandria, and recommends the dissection of apes and other animals which approach nearest to the structure of the human subject. Many of his anatomical descriptions are remarkably accurate. He made important discoveries in myology; and his knowledge of the nervous system appears to have been extensive. He practised surgery with considerable success at Pergamus; but in Rome surgery appears to have been held in disrepute, and he for the most part confined himself to the operation of venæsection when in the course of his medical practice this proceeding was required. On some occasions, however, he was more bold in operating, as we may infer from the fact of his having once applied the trephine to the sternum in a case of empyema. He seems to have taught the mode of performing surgical operations, and speaks of models of instruments that he was in the habit of showing in public. Three times he detected a dislocation of the femur forwards, and twice he observed a spontaneous displacement of that bone. He paid much attention to the use of plasters, ointments, and fomentations in all external affections; also to the art of applying bandages, and the employment of complicated machines for the treatment of fractures and dislocations.

Followers of Galen.

From the time of Galen until about the middle of the seventh century no advance was made in the science of surgery, and we meet with few names deserving of any notice. The practitioners of the third and fourth centuries are described as mere compilers, blind empirics, or miserable imitators of Galen. So implicit was their faith in every dictum of their great master, that the mere fact of any doctrine being contrary to his opinion was considered a sufficient proof of its fallacy. It was during the period of which we are speaking that literature in general was fast decaying, and the progress of science and learning was suspended, medicine sharing the fate of all other departments of knowledge. During these dark ages we find the names of a few individuals who recommend themselves to our notice, more on account of their having preserved the medical knowledge handed down to them by their predecessors, than from their having contributed in any material degree to its advancement. Oribasius was a practitioner who lived about the middle of the fourth century; his writings are chiefly compilations from the works of Galen and other eminent authors.

Oribasius.

Ætius.

Ætius lived about the middle of the sixth century: he was born at Amida, in Mesopotamia; he studied at Alexandria, and afterwards practised at the court of Constantinople. His writings contain descriptions of some diseases and some modes of practice which we do not find noticed by any preceding author. He described numerous diseases of the eye, and operated for cataract by extraction. In cases of anasarca he made incisions on the inner side of the legs. He made frequent use of the actual and potential cautery for the formation of issues. He endeavoured to dissolve urinary calculi by administering internal remedies; when these means failed he practised lithotomy. He excised hæmorrhoidal tumors, and operated for aneurism.

Paulus Ægineta.

Paulus Ægineta lived about the middle of the seventh century: he also was one of the Alexandrian school. He has devoted one book exclusively to surgery: in this he describes the different modes of treatment adopted by the ancients, by his own contemporaries, and by himself; he relates the good or bad success of many of them: he evidently has the merit of being something more than a mere copyist, and sometimes even ventures to dissent from Galen and other great authorities. In speaking of lithotomy, he insists on the importance of a free external incision and a small incision into the bladder. He describes several varieties of hernia, and the mode of operating for the relief of strangulation. He gives an account of aneurisms, and describes the operation, which consisted in cutting into the tumor, and placing a ligature above and below. He gives the history and treatment of numerous diseases of the genital organs, and mentions fractures of the patella and of the pelvis.

In the year 641, Alexandria was conquered by the Saracens under Amr-Ebn Al-As, viceroy of Egypt. The conquerors, according to common report, tarnished their laurels by the barbarous destruction of the noble library of Alexandria; but the story is very doubtful, and it is probable that the disorders and tumults to which Alexandria had previously been subject, had already destroyed this valuable collection. But at all events some works escaped, and fell into the hands of those who were capable of appreciating their value. Among these relics were the writings of Galen and Hippocrates; and we are informed that, at an early period after the establishment of the Saracenic empire, they were translated into the Arabic language, and enlarged by copious commentaries.

The Arabians.

We must now take a rapid survey of Surgery after its transfer from Alexandria, and during the prolongation of its existence in Arabia. After the Arabians had completed the conquest of a considerable part of the civilized world, the calm which succeeded seemed favourable for the cultivation of the arts of peace, and many of their rulers were most liberal in their patronage of science and literature. About the end of the eighth century, a college was founded at Bagdad, and medicine was zealously cultivated; public hospitals were built for the benefit of students, and most of the works of the Greek physicians and philosophers were translated into the Arabic language.

The study of anatomy was strictly forbidden by the Mahommedan religion; the Arabians were consequently compelled to trust for their knowledge of this subject to the writings of the Greeks. This fact we may consider a sufficient explanation of the slight degree of advancement which the Arabians made in the science of surgery. The first Arabian writer of any note is Rhazes; his works are chiefly compilations from the Greek authors; he lived about the commencement of the 10th century. He cauterized the wounds inflicted by the bites of rabid animals, and administered emetics to evacuate the "black bile." He gives some good directions respecting the operative treatment of malignant tumors.

Rhazes.

Avicenna.

Avicenna was born A.D. 980, and died in 1036. His knowledge was considered sufficiently extensive to entitle him to be designated the "prince of physicians."

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Surgery.

However eminent he may have been as a physician, his surgical practice appears to have been in the highest degree inert and timid. He recommends the cure of cataract by depression, but considered extraction o dangerous proceeding. He did not operate in cases of hernia, even when strangulated.

Albucasis.

Albucasis, who died A.D. 1112, is among the most celebrated of the Arabian surgeons. One remarkable feature in his practice is the very general use which he made of caustics, by means of which he appears to have treated almost every local affection. According to him, hæmorrhage arising from a wounded artery may be arrested in one of four modes; by cauterization, complete division of the vessel, ligature, or the application of styptics. He describes the operation for fistula lachrymalis, which he performed by means of a singular instrument, provided at the extremity with a small wheel. Tracheotomy he considers useless when the disease extends beyond the bifurcation of the trachea; when practised, the membrane connecting the cartilages (not the cartilages themselves) is to be divided. His operation for stone resembles that practised by Paulus Ægineta; he describes the mode of cutting for stone in females. His treatment of fractures appears to have been attended with unnecessary severity and cruelty; indeed many of the surgical proceedings of the Arabians are unequalled in the torture which they must have inflicted upon those who were so unfortunate as to become the subjects of them. One mode sometimes adopted by them of arresting hæmorrhage from the surface of a stump, consisted in dipping the part into boiling pitch. Such was the Arabian school. The reputation which it enjoyed was very considerable, but this appears to have arisen rather from incidental circumstances than from any absolute merit which it possessed. We are indebted to the Arabians for the transmission of the works of the ancient Greeks, with the addition of certain insulated facts with respect to the description of diseases.

In anatomy, as we have before remarked, they were absolutely prohibited from making any advances. In surgery, some few improvements were made by Albucasis, but it is doubtful whether, upon the whole, the practice of surgery was not in a retrograde state during the period of which we are treating.

After the extinction of the Saracenic school, we have an interval of about 300 years, from the twelfth to the fifteenth century, during which the dark ages still remained enveloped in the deepest gloom; every department of science was neglected, and among others that of medicine fell into the lowest state of degradation.

School of Salerno.

In the beginning of the eleventh century, a medical school was established at Salerno, and obtained a degree of celebrity from its local situation, this city being one of the great outlets by which the crusaders passed over from Europe to Asia, in their expeditions to Palestine; and it was probably from this circumstance that Robert of Normandy stopped at Salerno, in order to be cured of a wound which he had received in the holy wars. No improvements appear to have emanated from this school, but it is in one respect deserving of our notice, as it appears to have been the earliest establishment in which what may be styled regular medical diplomas were granted to candidates, after they had passed through a prescribed course of study, and been subjected to certain examinations.

In the year 1163, the council of Tours prohibited the clergy, who then shared with the Jews the practice of medicine and surgery in modern Europe, from undertaking any bloody operation. It is to this epoch that the true separation of medicine from surgery must be referred. The latter was now abandoned to the laity, the generality of whom, in those ages of barbarism, were entirely destitute of education. The priests, however, still retained that portion of the art which abstained from the effusion of blood, and disgraced surgery by reducing it to a mere business of applying ointments and plasters. Gilbertus Anglicanus is the first surgeon among our own countrymen whose name is handed down to us. He appears to have been an industrious compiler, and to have taken great delight in scholastic disquisitions and theoretical speculations. He lived about the beginning of the XIVth Century.

Separation of Medicine from Surgery.

Gilbertus Anglicanus.

During the XVth Century two events occurred which have an interest connected with the history of surgery.— The first of these was the discovery of the art of printing, about the year 1450. Towards the end of the XVth Century syphilis first broke out, and is said to have been imported from America by the followers of Colombus, but this account of its origin is doubtful.

XVIth Century.

At the commencement of the XVIth Century, the science of surgery was in a most degraded and unpromising condition; the most skilful practitioners appear to have had an invincible repugnance to all important operations, which they were content to leave to the ignorant charlatans of the day. In imitation of the Arabian school, too, they took great delight in the invention of numerous instruments and machines, each successive one more complex than the preceding, and thus they encumbered their art with new difficulties.

Beneveni.

At length Antonio Beneveni, a physician of Florence, began to insist upon a truth of the highest importance to the extension of surgical knowledge, viz.: that the compilations of the ancients and Arabians ought to be relinquished for the observation of nature. A new era now began.

Vesalius.

The moderns were convinced that by treading servilely in the footsteps of their predecessors they should never even equal, much less surpass them. The labours of Vesalius also gave birth to anatomy, illuminated by which science surgery put on a different aspect, and assumed a higher rank. The most celebrated surgeon of the XVIth Century was Ambroise Paré, a native of Laval, surgeon to king Henry the Second, Francis the Second, Charles the Ninth, and Henry the Third of France. Paré practised his profession in various places, followed the French armies into Italy, and acquired such esteem, that his mere presence in a besieged town was enough to re-animate the troops employed for its defence.

Ambroise Paré.

His writings, so remarkable for the variety and number of the facts they contain, are eminently distinguished from all those of his time, inasmuch as the ancients are not looked up to in them with superstitious blindness. Freed from the yoke of authority, he submitted everything to the test of observation, and acknowledged experience alone as his guide. He was the first to reduce the treatment of gun-shot wounds to rational principles. He treated hydrocele by the seton. He revived the use of the ligature in the treatment of hæmorrhage. He distinguished fracture of the neck of the femur from dislocation of the head of the bone, with which it had previously been confounded. He performed tracheotomy with success, and endeavoured



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Surgery. Ambroise Paré.

to cure fistula in ano by means of a ligature. His superior merit soon excited the ignorant, the jealous, and the malignant against him; and he became the object of a bitter persecution, his discoveries being represented as a crime; his fame however has survived him, and the French writers are with reason proud of their countryman Paré to this day. After the death of this great man, surgery, which owed its advancement to him, continued stationary, or even took a retrograde course. At this time the practice of surgery was associated with that of the barber, and the class of barber-surgeons continued to exist, both in this country and on the continent, for a period of nearly two hundred years. Pigrai, the successor of Ambroise Paré, was by no means an adequate substitute for him. A spiritless copier of his master, he abridged his surgery in a Latin work, when the unaffected graces of the original, the sincerity, and the charm inseparable from all productions of genius, entirely disappeared.

XVIIth Century.

In the next or XVIIth Century a fresh impulse produced additional improvements. There appeared in Italy, Cæsar Magatus, who simplified the treatment of wounds; Fabricius ab Aquapendente, the preceptor of Harvey, and less noted as a surgeon than as a physiologist; and Marcus Aurelius Severinus, the restorer of operative surgery.

English Surgery. Wiseman.

Among English practitioners during the XVIIth Century, we find the names of Richard Wiseman and William Harvey. Wiseman was a surgeon in the civil wars of Charles I., and accompanied Prince Charles, when a fugitive in France, Holland, and Flanders. He served for three years in the Spanish navy; in 1652 he settled in London. When Charles II. was restored he was made serjeant-surgeon to the king. He has given us the result of his experience in eight surgical Treatises on Tumors, Ulcers, Diseases of the Anus, Scrofula, Wounds, Gun-shot Wounds, Fractures and Dislocations, and Syphilis.

Wiseman merits the highest praise for the candour and honesty which are displayed throughout the whole of his works. His object in writing is evidently not so much to gain the repute of a skilful and successful practitioner, as to relate every fact which may be of benefit to his readers. He faithfully narrates not only the successful, but the unfortunate cases which came under his notice: the latter, as he remarks, being frequently more instructive than the former. His account of the symptoms and treatment of strangulated hernia is well worthy of perusal; and his Essay on Injuries of the Head is remarkable for the sound principles therein inculcated. He made great improvements in the treatment of gun-shot wounds, refuting the notion then generally prevalent, that such injuries had superadded to them some poisonous effect, which rendered necessary a peculiar plan of treatment. He gives excellent rules for the performance of amputation after gun-shot wounds of the extremities; and insists on the importance of amputating at once, before the occurrence of fever, in every case where the extent of the injury renders probable the ultimate loss of the limb. With all the sound sense, correct reasoning, and accurate observation displayed in Wiseman's treatise, it is curious to find him assenting to the popular delusion respecting the cure of scrofula by the king's touch. He declares that this sanative power was possessed by our kings, "At least from Edward the Confessor downwards." Of Wiseman we may say, in conclusion, that he effected for surgery in this country what Paré did in France, and is equally deserving of the grateful remembrance of his countrymen. A contemporary of Wiseman was William Harvey, whose name is rendered immortal by his discovery of the circulation of the blood. He publicly taught his new doctrine in London in the year 1619; but his work on the circulation was not published until 1628. The promulgation of this new doctrine brought on him the most unjust opposition, some condemning it as an innovation, others pretending that it was known before; however, he had the satisfaction of living to see the truth fully acknowledged and established. The discovery of Harvey, considered with reference to its effects in improving the science of surgery, must be esteemed the most important which has ever fallen to the lot of an individual to make. Before the circulation of the blood was known, how vague must have been the notions of the pathology, and how uncertain the methods of treatment of many of the most important surgical diseases, which are now comparatively well understood and efficiently treated! Our knowledge of the causes and the treatment of aneurism, the means which nature employs to arrest hæmorrhage, and the artificial methods calculated to effect the same purpose, are entirely based on the discovery of Harvey. For, although the ligature was occasionally applied to arrest hæmorrhage many years previously, they who used it must have been quite unacquainted with the true principle of its action, and the different modes of its application. The benefits which the knowledge of the circulation conferred upon the science of medicine are not less than those which surgery derived from it; indeed it is scarcely possible to overestimate the discovery of our illustrious countryman.

Surgery. Harvey.

Germany. Fabricius Hildanus.

Germany, during the XVIIth Century, boasted of Fabricius Hildanus, a successful practitioner, and author of a surgical treatise, dated 1641; Scultetus, so well known for his work intitled *Armamentarium Chirurgicum*; and Purmann and Solingen, who had the fault of being too partial to the use of numerous complicated instruments.

Holland.

Holland, restored to liberty by the generous exertions of her inhabitants, did not long remain a stranger to the improvements of surgery. There is one peculiarity connected with these improvements which claims the notice of the historian. Ruysch, who was an eminent anatomist, carried with him to the grave the secret of his admirable injections. Roonhuysen also made a secret of his lever, which before the invention of the forceps was the only resource in difficult labours. Raw, who successfully cut fifteen hundred patients for the stone, took such pains to conceal his manner of operating that Heister and Albinus, his two most distinguished pupils, have each given a different explanation of it. Such a disposition would materially have retarded the progress of surgery in Holland, had not Camper, in the following century, effaced the imputation by the great number of his discoveries, and his zealous desire to render them public.

Ruysch. Camper.

France.

From the time of Paré, until the commencement of the XVIIIth Century, surgery was but little cultivated in France. Mauriceau, Saviard, and Belloste, were the only French surgeons of note, who could be contrasted with so many eminent men of other nations. During the XVIIIth Century, France produced two surgeons of extraordinary genius; these are Petit and Desault. Petit was one of the first and most distin-

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Surgery. Petit. guished members of the Royal Academy of Surgery. At an early period of his life he published his *Traité sur les Maladies des Os*, a work which was long esteemed the best on the subject. To him we owe the invention of the screw tourniquet. His progress was most violently opposed by envious critics, and it was not until after many years of labour that his superiority was acknowledged, and he was unanimously elected the head of his associates. Desault. Desault has the reputation of an accomplished anatomist and a skilful surgeon. He invented the straight splint for fracture of the thigh; the simplicity and usefulness of which is now a matter of daily observation. About the same period flourished the following eminent French surgeons; Le Dran, Morand, Chopart, Mareschal, Garengeot, Louis, Sabatier, Quesnay, Maître Jean, the inventor of the Lithotome Caché, Le Motte, Le Cat, &c.

XVIIIth Century. During the XVIIIth Century, Great Britain could boast of the following celebrated names:—Cheselden, the two Monros, Cowper, C. White, Pott, Hawkins, Smellie, and Hunter. The name of Cheselden is so intimately associated with the operation of lithotomy that a short notice of the various modes of performing the operation may, appropriately, precede our account of the improvement which he effected. Cutting for the Stone. The most ancient kind of lithotomy was that practised more than two hundred years ago by Ammonius, of Alexandria. It is the same as that described by Celsus, and has been called *cutting on the gripe*, or the *apparatus minor*. In operating by this mode two fingers were placed in the rectum, the stone was pushed forwards, and made prominent on the left side of the perinæum. A lunated incision was then made through the skin and cellular tissue, directly on the stone, near the anus, down to the neck of the bladder. Then a second incision was made on the stone into the neck of the bladder. The calculus, being strongly pressed upon by the fingers, next started out of itself, or was extracted with a hook constructed for that purpose. The operation by the *apparatus major* was first published by Marianus Sanctus, in 1524, as the invention of his master, Johannes Romanus; it was founded on a dictum of Hippocrates, that *wounds of membranous parts are mortal*. A grooved staff was introduced into the urethra; the membranous part of the canal was opened, an instrument was passed through the prostatic portion of the urethra by which the prostate was forcibly dilated and lacerated; when this was carried to a sufficient extent, the stone was extracted by forceps. The *high operation* was first practised in Paris, in 1745, by Colot. In operating by this method an incision was made in the median line above the pubes; the bladder was cut into, and the stone extracted by forceps. The lateral operation was invented by Franco, and subsequently improved by Frère Jacques, who came to Paris in 1697, and cut many patients at the Hôtel Dieu and La Charité. Frère Jacques used a large round staff, in his early operations, without a groove, but afterwards he adopted a grooved staff. After the introduction of the staff he plunged a long knife into the left hip, near the tuber ischii, and pushing it towards the bladder, opened it in its body, or as near the neck as he could. The improvement which Cheselden effected upon this last operation consists in opening the bladder by cutting through the left lobe of the prostate; and in his last modification of it he first plunged the knife into the bladder behind the prostate, and then divided the latter, as well as a part of the membranous portion of the urethra, from within outwards. Surgery. The lateral operation, with the internal incision not carried beyond the prostate, is the one almost invariably adopted at the present day.

Percival Pott. Percival Pott contributed greatly to the improvement of surgery in England, by abolishing many of the severe and painful measures which were previously in vogue, by the introduction of more rational modes of treatment, and by his admirable descriptions of surgical diseases and injuries. We need only allude to his account of injuries of the head, and their treatment; his history of diseases of the vertebræ, attended with paralysis of the limbs; his celebrated essay on fractures, and his valuable remarks on amputations. He is spoken of as being in his time "the best practical surgeon; the best lecturer; the best writer on surgery; the best operator of which this large metropolis could boast." A man of greater genius and originality than Pott was John Hunter, who was at once eminent as a surgeon, an anatomist, a physiologist, and a naturalist. John Hunter. An enumeration, in this place, of the invaluable improvements which he made in the practice of surgery is impracticable; we would refer our readers to his treatises on inflammation, on the blood, and on the venereal disease, and would especially direct attention to the vast improvement which he effected upon the old operation for aneurism. Before the time of Hunter, the operation was performed by cutting into the sac of the aneurism, and tying the vessel above and below. So formidable was this proceeding in its consequences, that amputation of the limb was frequently preferred as a less dangerous and fatal measure. The genius of Hunter led him to tie the femoral artery in a case of popliteal aneurism, leaving the tumor untouched. The safety and efficacy of this mode of operating have now been fully established, and the principle has been extended to all operations for the cure of this formidable disease.

Italy. While in Great Britain the preceding distinguished men were raising the character of their profession, Lancisi, Morgagni, and others were pursuing a corresponding honourable career in Italy. Of late years, the credit of the Italian school has been well maintained by Monteggia, Scarpa, Assalini, and others. In Holland flourished Albinus and Camper. In Germany, Haller, Heister, Soemmering, and a long list of zealous and successful cultivators of anatomical and surgical science.

Present Century. In the rapid enumeration which we are giving of the names of those individuals who have chiefly contributed to raise surgery to the high position which it at present occupies, we must not omit to mention the names of Baron Dupuytren, Abernethy, and Sir A. Cooper. The former has lately closed a career of unusual brilliance in Paris, leaving behind him a series of highly valuable observations on most of the great subjects of surgery, and a reputation for boldness, skill, and judgment, the remembrance of which will not speedily be effaced. John Abernethy was eminently distinguished both as a practical surgeon and a philosopher, and by his enlarged views and sound understanding did much to extend the application of Hunter's doctrines to the management of disease. In particular he strove to impress on the minds of surgeons the reality and importance of the connexion existing between various local maladies and an impairment of the



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Surgery.

general health, in his celebrated Essay on the *Constitutional Origin and Treatment of Local Diseases*, a treatise that exercised great influence over the profession at the time of its publication. Sir Astley Cooper has more recently terminated a life marked by zeal and activity which remained unabated even to its very close. "His published works will remain as long as surgery is cultivated, and especially the treatises on Hernia and Dislocations, replete with important facts, and containing the clearest rules of diagnosis, will transmit his name to posterity with those of Sydenham and Hunter, as a benefactor to the human race."

Sir A. Cooper.

Influence of war on the progress of Surgery.

In looking back on the history of Surgery, we may remark that its progress has been singularly influenced in two ways: viz., by war—and the institution of hospitals. The wars of civilized nations have seldom proved unmitigated evils, and one of the benefits they have conferred has been the encouragement they have afforded to the cultivation of surgery. Perhaps the earliest recorded instance of the regular practice of this art is to be found in Homer, as having occurred at the Trojan war; and even though we reject the authenticity of the narration, as matter of history, it must at least be admitted as evidence that such pursuits were systematically followed by a particular family or class, as remotely as the age of the poet. Ambrose Paré, the great reviver of surgery in France, and Wiseman, the father of English surgery, were both trained and taught in this school; and it may be doubted if in any other they could have contributed so largely to its improvement. In the camp and in the field, indeed, the intellectual energies of those on whom the safety of their fellows depends, are awakened in a way to which the ordinary occasions of civil life afford no parallel. In later times a host of eminent names attest the benefits derived to science from this great source of experience.

Hospitals.

With regard to hospitals, we cannot do better than quote the following remarks of Mr. Arnott, lately made in a lecture delivered at King's College, London, on the occasion of the establishment of the hospital, now connected with that institution, and bearing its name.

"Before the introduction of Christianity," says Mr. Arnott, "Hospitals were unknown. Among the most polished nations of antiquity, the Greeks and Romans, it is in vain to seek either in their annals, or in the remains of their once proud cities, for a trace not only of hospitals, such as they now exist, but of any charitable institutions for the reception of the poor, the orphan, and the sick.

"After the introduction of that religion which looks upon all men as equal, and which inculcates charity as a duty, its disciples at an early period contrived a scheme for the assistance of their necessitous brethren; but this did not, until the fourth century, assume the form of institutions for their reception. * * * As there were then no inns for the accommodation of strangers, when in foreign countries or at a distance from home, it was usual for travellers of that nation (the Roman) to be received at the houses of certain persons, whom they in their turn entertained in Rome. The connexion thus established was considered an intimate one, and was styled '*hospitium, jus hospitii*.' The former term was also applied to the reception of a stranger, and to the house or apartments in which he was entertained; and the Roman nobility used to erect the latter, called *hospitalia*, on the right and left ends of their houses, with separate entrances. From these our 'hospital' is derived. * * *

Surgery. Hospitals.

"With the institution of religious orders, a prominent part of whose duty it was to solicit alms, to tend the sick, and to succour the afflicted, the number of hospitals increased, and from this source it is ascertained that some of the oldest and largest hospitals in this and other countries of Europe have arisen. St. Bartholomew's was originally connected with a priory, as likewise was St. Thomas's, both hospitals being in existence centuries before the time of Henry VIII. La Charité arose in the same way, and the Hôtel Dieu was attached to the adjoining Cathedral of Notre Dame. * *

"Originating with the Christian priesthood, often associated with the principal church of the places in which they existed, and very generally constituting a part of some religious house, it was natural that the care and management of all hospitals should primarily devolve on the clergy,—on those through whose aid, and presumed powers of intercession with Heaven, restoration to health was looked for and expected. Nor is it surprising that this control should have been retained during the dark ages, and even for a considerable time after the general revival of intellectual activity in the twelfth century. * * It was not until a considerable time subsequently that the influence of hospitals upon the progress of medicine was felt—not until it had been preceded by the more ardent and successful cultivation of anatomy in the sixteenth and seventeenth centuries, and in this country not until there had been adopted less stringent regulations with respect to the admission of pupils to these charitable institutions.

"At the commencement of the last century there were but two hospitals in London for the sick and lame—St. Bartholomew's and St. Thomas's; and the governors of these wholly refused to allow the education of pupils in the one, and would only admit nine at a time in the other. They afterwards relaxed, and in somewhat more than half a century later, had so completely changed their views that they built and attached theatres to their hospitals, for the teaching of anatomy and the lecturing on surgery, which up to this time had been carried on in private establishments only. St. Thomas's had the priority in this respect, the anatomical theatre having been built there in 1768; at Bartholomew's, although Mr. Pott was appointed lecturer on surgery in 1765, an anatomical theatre was not built till twenty years afterwards. These changes, together with the ready access of pupils to the more recently erected hospitals, had most important effects on the progress of medicine. As an evidence of this, consult the works produced on surgery since the first third of the last century, the Memoirs of the French Academy, the writings of Pott, Hunter, Petit, Desault, Sabatier, Abernethy, Home, Boyer, Scarpa, Hey, Dupuytren, Cooper, Delpech, and of many minor and other living surgeons, and it cannot fail of being remarked how much of the statements, of the opinions, and of the practice of the authors, is based upon the observations made in and on the experience furnished by the hospitals to which they were respectively attached. * * * *

"There, also, patients are placed in circumstances and under a degree of control much more favorable than elsewhere for witnessing the course and termination of disease, for ascertaining the effects of remedies, and for investigating, in cases of fatal result, the appearances

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Surgery. Hospitals.

met with after death. No other institutions afford equal opportunities for acquiring a familiarity with operative surgery—not only the operations themselves, but the treatment of the cases before and afterwards. * * *

"From what has been stated, it will have been inferred that the value of hospitals as schools of medicine has been for a considerable time felt and acted upon in England. But the best method of making available these advantages has only been pursued within a very limited period. In so far as brief remarks, made occasionally and regularly at the bedside, constitute clinical instruction, this has probably been practised from the first admission of pupils to these institutions. But the system of taking individual cases of disease, and making them the subject of lecture, was in the first instance adopted in Holland, at Utrecht, and Leyden. Thence it extended to Pavia, Vienna, and Edinburgh, and was for a long time confined to these schools, and applied to physic only. Desault, in the Hôtel Dieu, first employed the method systematically in the teaching of surgery. In this metropolis it was, I believe, first introduced by Sir C. Bell. The regular application, however, of clinical teaching in both departments of medicine as an essential part of education, is but of yesterday."

## Operations.

Operations have been called the opprobria of surgery; and where they are ill-advised or ill-executed, they may be deemed justly liable to this condemnation. In the days when the most important operations were commonly performed by empirics, whose impudence and conceit were only equalled by the profoundness of their ignorance,—and when even those few professors who were best versed in the subject were for the most part unacquainted with anatomy, and could only employ for the arrestation of hæmorrhage means both barbarous and inefficient, operations were naturally looked upon as revolting expedients, for the terrors of which their ill success could afford but a poor compensation. But a little reflection will show that it is unfair to charge that as an inherent disgrace on surgery which is imputable only to the darkness of a by-gone age, or to a want of knowledge, or judgment, or principle, on the part of its individual professors. We will even so far put ourselves into the position of advocates as to say that operations such as are now so extensively practised with judgment, humanity, and skill, are the glory of surgery, and are likely to remain so, as long as man continues obnoxious to accident and disease. What can be a more noble exercise of art than to save life and prevent or terminate protracted suffering by a speedy and dexterous operation? When, for example, some foreign substance has dropped into the windpipe, and threatens impending suffocation, what an admirable and rational interposition is that by which the surgeon opens the tube below the narrow chink at its orifice, and gives exit to the offending substance. What numerous instances do we not know to have occurred where this accident has, without this seasonable interference, proved quickly fatal. Or again, in that frequent and dreadful malady which consists in the slow formation of an earthy concretion in the urinary bladder, attended as it usually is by the most severe tortures, making life unendurable long ere it exhausts it by the gradual effects of pain and organic disease; how worthy of commendation is that brief procedure by which the practised surgeon apprehends and removes the source of his patient's misery! And a thousand examples might be added to these in proof of the same thing.

Surgery. Operations.

It is indeed but too true that, even in the present day, operations are often undertaken and performed with but small chance of benefit, and that some of those which appear promising in their results eventually prove useless, and even accelerate a fatal issue. Sometimes this arises from idle or hopeful delay on the part of the sufferer or his friends, until the most propitious season is past; sometimes from the oversight or irresolution of the surgeon; and very frequently from the originally disastrous and malignant nature of the disease itself. Some operations are essentially dangerous from the structures involved, or their proximity to deep-seated or vital organs; some from the constitutional debility or cachexy of the general system; and others from the deficiency of the means and attendance which the subsequent progress of the case may demand. And the universal experience of surgeons declares, that not even the most trivial operation can be pronounced absolutely free from danger, since it may prove the starting point of a spreading and fatal inflammation, or of some disproportioned sympathetic affection of the nervous system (such as tetanus), of which the progress of knowledge has not yet divulged either the nature or the remedy. But making due allowance for these and many other circumstances, which in actual practice present themselves under ever-varying complications, we must conclude that they are rather difficulties and uncertainties referable to the imperfection of our control over vital actions, than blemishes on the art of surgery. Practical wisdom must decide that, taking circumstances as they are found in reality to be, operations must, in numberless cases, prove an inestimable blessing to mankind.

But while we say this, we would point with extreme satisfaction to the progress of modern surgery in alleviating the suffering and danger of operations, and in materially restricting their numerical amount. By a more exact acquaintance with surgical anatomy, by a more dexterous use of instruments by surgeons in general, and more especially by an early resort to those prophylactic or remedial measures which ward off the dreadful necessity for the knife, the future historian of Surgery will probably characterize the main tendency of the improvements of the passing age. But it will also be a signal distinction of our own day, that many new procedures have been devised to remove diseases or unsightly deformities formerly set down as incurable; and that many old ones have been supplanted to a greater or less degree by others adapted to the improved state of physiology and medicine. We shall exemplify these remarks when recounting the treatment of particular maladies.

Deciding on operations.

*Deciding on Operations.*—It is difficult to lay down any general rules on this subject, in consequence of the infinite variety of circumstances in different cases. Many operations are urgently demanded for the immediate preservation of life. Such, generally, are those for strangulated hernia, for fractures of the skull with depression, and very many more. Others may be safely delayed for a certain length of time, without prejudice to the patient's welfare, such as lithotomy or lithotrity under many circumstances; while others of minor im-

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portance may be regarded more or less as measures of convenience rather than of safety, and will admit of being deferred until every circumstance shall appear the most favourable. In these latter cases, every prudent surgeon will consult the well-being of his patient not less than his own reputation, and that of his art, by a careful selection of the period of operation. Winter and spring are usually the best seasons in which to undertake operations; and autumn is the worst, on account of the atmospheric condition, and the frequent prevalence of erysipelas, especially in hospitals, at that time. Hot weather makes recovery more difficult, and increases debility and prostration, both by encouraging cutaneous evacuations, and by directly depressing the nervous system. It also appears to augment the tendency to undue vascular action in wounds. In some seasons erysipelas is epidemic, and it is apt to linger in an endemic form where it has once committed its ravages. Under either of these circumstances, all those operations must be avoided that are not absolutely necessary.

In judging of the propriety of an operation, the state of the whole system and of the internal organs must be carefully inquired into. Want of attention on this head, has often led to the infliction of needless suffering, and even hastened instead of retarding the fatal termination. Thus we have ourselves witnessed the performance of an amputation for the removal of a foot, the bones of which were disorganized by struma,—and where the unhappy boy bore within him the somewhat advanced seeds of consumption, to which disease he fell a victim a few weeks afterwards. Thus also in malignant disease, the general voice of the profession conspires to condemn its removal by the knife, where there exists sufficient evidence of its presence in parts to which this remedy cannot be applied: and some surgeons are even disposed to the plan of non-interference in many instances, where such evidence is far from being conclusive. Under all circumstances, calmness and resignation in the patient will be hailed as the omens of a happy result, and the opposite conditions of alarm, irritability, and excitement must weigh heavily against him. On this account, when an operation is resolved upon, an important part of the surgeon's duty will be to re-assure his mind by kindness and encouragement, which will be done more effectually by a mild and cheerful behaviour than by words. One under the anxiety of an approaching operation, the magnitude and pain of which his fears will incline him to overrate, and which seems critical of his fate, will derive from this source an amount of consolation and fortitude only to be conceived by those who have been in the position to experience them.

It will be advisable to prepare the system for the shock it is about to sustain, by employing those measures which have a tendency to restore strength or to diminish plethora. The functions should all be brought into as healthy a condition as the time and circumstances will allow. With some surgeons it is a favourite practice to reduce the powers of the system below the natural standard, with the view of diminishing the chances of subsequent inflammation. In some peculiar cases, where this accident, even though slight, might put an important organ in jeopardy, and mar the success of the operation, as in extraction of the cataract, this is generally adopted as a prudential step; but as a practice before ordinary operations, it is universally discarded, at least in this country. There is, on the contrary, a growing opinion in favour of a more free exhibition of tonics and stimulants, both before and after the great operations; and experience seems to declare that, at least in capital cities and among large manufacturing and commercial communities, such a course is indispensable.

With respect to the conduct of an operation, it has been well said that "three things are required,—a cool head, a quick eye, and a steady hand." Much must be given by nature, but more by education, to form the distinguished operator. He must possess coolness, presence of mind, and a certain physical strength of purpose, which will not allow itself to be diverted from the object which the judgment has sanctioned, by any ill-timed weakness or vacillation. But these valuable endowments could only lead to the most culpable rashness in an operator who was deficient in those more solid qualifications which knowledge alone can supply. He must be well and practically versed in the anatomy of the body, particularly of those regions which are liable to diseases calling for his interference; and he should moreover have studied the changes which disease or injury may work in their texture, or relative situation, so that when he encounters unnatural conditions, he may not be dismayed and thrown off his guard by his inability to comprehend their import.

Before commencing an operation, it is essential that everything requisite for its completion should be at hand, that delay may not be occasioned when it is so little compatible with the welfare of the patient. With this view, the whole should be previously pondered in the surgeon's mind, every step dwelt upon, and possible contingencies foreseen; he should have first operated *in imagination*. His instruments will be then at hand and in good order, there will be duplicates of those which may be liable to injury, and he will be furnished with means for arresting hæmorrhage. If the proceeding is conducted by candle-light, he will have several lighted in case of accident. The patient should be placed in such a posture as may best conduce to the successful performance of the operation; and his own ease should be consulted, that he may not be fatigued ere it be finished. This is a circumstance that is more attended to in the present day than formerly, especially in our public hospitals. But in some particular cases, such as lithotomy, it is still an universal practice to fix the patient so that he cannot change his position by his struggles—an accident likely to be followed by the most unfortunate consequences, in an operation where so many important parts are crowded together in the small region in which it is performed.

"Everything being got ready," says Le Dran, "the Surgeon begins the operation, which should be done *expeditiously* and *effectually*; expeditiously, because every moment of suffering appears long: nevertheless the operator must allow himself sufficient time, and when I used the word *expeditiously*, I only meant that he should not lose time, taking great care not to be over hasty, lest his hand out-run his judgment, which should direct it. An operation is always soon enough done that is well done. He is likewise to operate effectually, that is, in such a manner as not to be obliged to renew the operation, or to make fresh incisions. If the case requires that the operation should be done at twice, or if he plainly foresees there will be abscesses and sinuses which must be afterwards opened, he ought to mention this beforehand, to prevent the patient

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being alarmed when it happens, as well as to preserve his own character. In performing the whole, he should endeavour to give as little pain as possible, and not to incur the imputation of cruelty."

Amputation.

We shall conclude this subject with some remarks on one the most important operations in surgery, viz., *amputation.*

By this operation, a limb or other projecting part of the body is cut off. When it has been determined to sacrifice a member on account of disease or injury, the surgeon's attention is directed principally to three points, viz.:—to prevent unnecessary hæmorrhage—to provide a useful and healthy stump, and to heal the wound with speed. Where arteries of large size are necessarily divided, the bleeding abandoned to itself would be fatal. It is therefore requisite to compress the main artery of the limb before the operation is commenced. This is usually done by means of an instrument devised for the purpose, and called a *tourniquet.* This consists in a girth encircling the limb, and capable of being tightened or slackened at will by a simple contrivance moved by a screw—and its effect of pressure on the main vessel is increased by a compress of cork or other material adapted to that part. But this apparatus is by no means essential to the prevention of hæmorrhage, and in the case of many arteries, such as those of or near the trunk, it cannot be employed —many surgeons reject it altogether, preferring the judicious and well regulated compression of the artery by the finger or thumb of an assistant familiar with the anatomy of the parts. It is certain that a very slight pressure, rightly applied, will be amply sufficient to obstruct the flow of blood through the vessel, and the tourniquet is liable to the objection of giving the same sense of security, whether it is well or ill applied. When used, it should always be adapted to the limb by the surgeon himself, and especially when he has not full confidence in his assistants. When the limb is off, the orifices of the divided vessels are seen on the surface of the stump. They are then to be taken up, and secured by ligatures on the principles which will be explained under the head of hæmorrhage—after which the pressure on the arterial trunk is to be removed.

To provide an useful and healthy stump, many circumstances must be duly weighed and attended to. The principal object is to secure an ample covering of soft parts, especially of skin for the end of the bone, otherwise this will protrude by the recession of the muscles, and will then exfoliate, and to say the least, will necessitate another operation, and after all leave the limb more or less useless. Such were the lamentable conditions consequent on the old amputations—and which ensue on the natural process of separation of a limb which has perished by mortification. To obviate such occurrences, the surgeon has to shape his incisions in a particular fashion—the great object of which is to divide the bone at a higher point than the investing structures, so that even after the retraction of these consequent on the elasticity of the skin, and the contractibility of the flesh, there may be enough substance left to be brought over the end of the bone, and to give it an abundant cushion-like covering. Two methods are currently practised with this end in view, of which we may here offer a short account. These are the *circular* and the *flap* operations.

Circular Amputation.

In the *circular* operation, the knife is first carried transversely round the limb, through the skin and subcutaneous fascia only. These structures are then dissected upwards from the deep fascia and muscles for an inch or more, according to the size of the limb and the extent of covering required. The second incision is then made through the muscles at the highest point at which they are exposed by the previous dissection, and they are divided either at one or two strokes, down to the bone. They are then usually pulled upwards by an assistant, and a still higher section made of those fibres that lie close to the bone. Thus the bone is exposed on a level from three to six inches higher than the first incision through the integuments. The bone is now sawn through with an ordinary saw, the fleshy parts being, by many surgeons, held back by means of a piece of linen, called a retractor, adapted to preserve them from injury by the saw. The employment of the retractor will be determined by the circumstances of the individual case.

Amputation by flaps.

In the *flap* operation the skin and muscles are cut at once in a slanting direction on each side of the bone, and the latter divided at the acute angle thus formed between the flaps; so that the dissection of the skin from the muscles is avoided, and the operation is thus shortened. The flaps are usually made by first thrusting the knife through the limb close to the bone, and cutting outwards and downwards, but they may be made by commencing on the outside and cutting upwards towards the bone. The former, however, is in general both the more expeditious and the more easy plan. There always remain some few fibres near the bone, which have to be divided by a circular sweep of the knife, after which the flaps are held back, and the bone sawn through, as in the circular method.

It is not our intention, nor is this the place, to discuss at any length the comparative advantages of these two modes of operating. We shall confine our remarks upon them within very narrow limits. The circular method is the longer in its performance, but in the hands of a good operator it ought seldom to exceed a minute or two. The flap may generally be performed in even less time. The circular is attended probably with rather more pain, from the dissection of the skin from the muscles, which it entails, while the flap has the occasional disadvantage of dividing the vessels obliquely, and leaving the nerves long on the face of the stump, circumstances which may render necessary some little further cutting after the limb is already severed. With regard to the stumps that are to be formed by these two methods, it would appear that most excellent ones may result from both under proper hands and with suitable care. Of course the circular operation gives less fleshy stumps than the other, and affords a less mass of covering for the end of the bone. But the fleshy cushion that the flap affords often wastes remarkably at some period after the operation, and when pressure comes to be made habitually upon it. It is also more liable to include the extremities of large nerves, which when enlarged, as they usually become, into a bulbous form, may prove troublesome in the attempts to make the stump useful as a support. On the whole it must appear on a dispassionate view of the respective merits and demerits of the two methods, that there is so little essential superiority in either, that their adoption in practice will constantly be determined by the particular region operated on, or by the taste or fancy of the surgeon.

With respect to the third point we have adverted to,

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Surgery. Amputation.

viz. the speedy healing of the wound, we shall have little to say. In this country there happily exists no difference of opinion on the question whether the surfaces of the wound should at once be brought together within a few hours after the operation, to heal as much as possible by the first intention, or whether they should be kept apart by sponges or charpie, with the intention of inducing suppuration and slow union by granulation. It is the proud boast of English surgery that it was the first to advocate the former of these methods, and that it has always supported the practice by argument and example against the adverse opinions of some of the most eminent continental surgeons. If this plan be followed, the stump will be healed in ordinary cases in three weeks or a month, and it seems certain that no injury can arise from the judicious attempt to unite the wound by adhesion, even should that attempt unfortunately fail, for the surgeon will of course be on his guard to loosen the bandages, if the tumefaction or pain seem to indicate the necessity of doing so. The wound made by the amputating knife is to be treated on precisely the same principles as are applicable to ordinary incised wounds.

### Wounds.

Wounds.

1. The subject of wounds is one of great extent and importance, and has in all ages received a large share of attention from practical writers. These are common, obvious, and alarming injuries, frequently fatal, either immediately or in their remote consequences, and appeal by their very nature for instant and effectual aid. They require to be considered, first, in regard to their original condition, manner of infliction, parts implicated, extent of injury; next, in regard to their consequences, both local and constitutional, the reparative efforts of nature, and the causes of their failure, and thirdly in respect of treatment.

Kinds of Wounds.

1st. Wounds are divided into Incised, or those inflicted by cutting instruments; Punctured, or those arising from the thrust of a pointed weapon (of these stabs are an important variety); Lacerated, where the parts are torn, as by a hook dragged through them; and Contused wounds, or bruises. Of these the several characteristics are the following. In *Incised* wounds the structures are simply divided, they continue living, their relative position and internal texture is little disturbed, and if they are brought into contact and retained long enough, they will readily unite, in a healthy person, by the process termed *adhesion*, or the *adhesive inflammation*. When this is effectually accomplished the part or organ is as nearly as possible in the same condition as it was before the injury. *Punctured* wounds implicate parts at a greater or less depth, through a small aperture in the skin. The instrument insinuates itself between the textures, and displaces them by stretching, rather than divides them. Hence such wounds are often more dangerous than they seem, and are apt to be followed by severer consequences than incised wounds. *Stabs* partake of the characters of both the preceding, and are, *cæteris paribus*, more dangerous than either; they may divide parts deeply seated, as muscles or vessels, in such a way as to make it very difficult to examine the nature and extent of the injury, to clear out coagula, secure bleeding vessels, or bring divided structures into apposition. Hence the repeated hemorrhage, distending the limb with blood, and the suppuration, with matter pent up and burrowing under fasciæ, which so frequently follow this form of injury. In *Lacerated* wounds the tissues are irregularly torn, and the neighbouring parts hurtfully dragged, often at a considerable distance from the immediate seat of injury. There is comparatively little hemorrhage, the vessels being torn in a way peculiarly adapted to favour the formation of a plug of coagulum in their orifices. (See *Hæmorrhage*.) These wounds are apt to implicate nerves to an extent of several inches in consequence of the toughness of their fibrous sheath; and hence apparently the greater frequency of tetanus as a consequence of them. They are often complicated by foreign bodies, as dirt, and are much less disposed to union by the first intention than incised wounds. They generally suppurate and heal by granulation. *Contusions* are caused by the forcible compact of some blunt heavy body. The skin escapes by its toughness and elasticity, while the subcutaneous textures, vessels, nerves, or muscles, are bruised or disorganized. The effusion of blood which ensues upon them is generally from vessels of small size, and extends in the interstices of the tissues, rendering them tumid, and imparting a livid hue, which subsequently, as the blood is absorbed, passes through several well-known shades before it finally disappears. In severe contusions over the viscera, as when the wheel of a carriage passes over the abdomen, it frequently happens that the deep-seated organ is crushed or ruptured, while the skin, and even the entire thickness of the wall of the cavity, escapes with only a trifling injury. This arises from the tough and yielding nature of the parietes, as compared with the fragility of solid organs, like the liver or spleen. Contused wounds are attended with more or less concussion and deadening of the part, which may or may not recover itself. If it do not, a slough ensues, inflammation runs high, and an abscess is formed around it. Wounds very commonly are contused and lacerated at the same time. Such are gunshot wounds, which, however, from their peculiar severity and other circumstances, require to be treated of separately.

Incised. Punctured. Stabs. Wounds, lacerated. Contused.

Wounds have also to be considered with regard to their complications, such as the presence of foreign bodies, of poisons natural or morbid; the co-existence of a fracture or the penetration of any of the important cavities or organs, as those of the head, chest, or abdomen. The subject of poisoned wounds has been already discussed (See MEDICINE); the other complications will be attended to in the present article, in their appropriate places.

Treatment

Having made these brief observations on the nature and varieties of wounds in general, we must pass on to their *treatment*, referring the reader to the article just mentioned, for information concerning the nature of the vital processes consequent upon them, both in the part and in the entire system.

of incised wounds.

The surgeon's course of proceeding is usually a very plain one in cases of incised wounds. In almost every instance the divided parts recede from one another by their natural elasticity, and it will be his duty to replace and retain them in contact. It is of course absolutely requisite, before this is attempted, that any foreign particles lodged in the wound be withdrawn. It sometimes happens that this cannot be effected, and then the parts are not to be brought together. For example, in cuts by glass, much unnecessary pain and inflammation are often induced by attempts to close the

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Surgery. Treatment of incised wounds.

wound while small fragments remain buried in the flesh. These cause inevitable irritation, and prevent union. Where they cannot easily be extracted at the time, the best application is a poultice of bread and water, suppuration succeeds, and the particles easily discharge themselves. When it is determined to attempt immediate union, the edges of the wound may sometimes be brought together by attention to the posture of the part, but in general some further artificial means are required. Straps of adhesive plaster are in common use for this purpose: they are cut of a convenient width, and applied across the wound, while its edges are brought into apposition by the fingers. Care is to be taken that they are not braced too tight to allow of the tumefaction usually ensuing, and it is advisable to leave intervals between them for serum or other superfluous fluids to ooze from the wound. In wounds of particular parts, or of great extent, stitches or *sutures* are necessary. For example, in wounds of very uneven or very moveable parts, as the lips, eyelids, or ears, they are commonly required, because plaster either could not be effectually applied or would soon become displaced. The ligature usually employed consists of ordinary strong thread or silk; which is passed through the lips of the wound at opposite points and tied. The number of these corresponds with the extent of the wound. They may be from a quarter of an inch to an inch or more apart, according to circumstances. This mode of putting in stitches is styled the *interrupted suture*, in contrast with that formed by a single thread passed repeatedly. The advantages it possesses are, that it can be regulated better, and can be withdrawn in parts as occasion may demand. In all cases foreign particles present in the wound are to be withdrawn, and even coagula cleared away, as they materially interfere with the adhesive process, if they are of any size. In removing them small vessels may begin to bleed again; but these will soon cease bleeding, and, if not, they may be secured by ligature, as explained under the head of *hæmorrhage*. It may sometimes happen that structures of considerable thickness are divided, in which it is very important that the whole depth of the wound should be accurately in contact. To effect this two modifications of the common suture are occasionally used, in the first of which (the *quilled suture*) two quills are placed, one along each side of the wound, and ligatures, passed deeply through it, are tied over them, so as to press together the deeper parts. The other, commonly known as the *hare-lip suture*, consists of one or more needles passed deeply through the lips of the wound, which are then secured in contact with each other by a thread twisted repeatedly over the projecting ends of the needles. This variety of suture is highly valuable wherever an accurate and firm adjustment of the surfaces of a wound is required. In all cases in which an attempt is made to effect union by the first intention, the surgeon must adopt every measure calculated to check undue vascular action, and to prevent the occurrence of that degree of inflammation which terminates in suppuration or sloughing, since these would be entirely incompatible with the desirable end in view. The antiphlogistic regimen and treatment are to be put in practice. If the edges of the wound are tender and red, discharging a thin serous fluid, the strapping should be removed entirely or in part, the suture cut through, so as to allow the parts to recede somewhat, and a soft poultice applied over the whole. If this be not done, the inflammation will probably advance and assume an erysipelatous character, the morbid secretions from the surface of the wound will be pent up, with an aggravation of all the symptoms, and the sutures will finally become detached by ulceration. When the adhesive process fails the wound heals by granulation.

Sutures. Interrupted suture. Quilled suture. Hare-lip suture

Surgery. Treatment of wounds.

Of punctured wounds.

In *punctured* wounds no apparatus is required to keep the divided parts together, and when foreign bodies have been withdrawn the efforts of the practitioner are directed almost solely, in the first instance, to the prevention or mitigation of inflammation. In addition to the general means adapted to this object, it is an essential part of the treatment to preserve complete rest in all cases where the wound is in a part liable to motion, as the muscles, or the neighbourhood of joints. The best course is to apply a moderately firm bandage to the whole limb, with the addition of a splint, if that seem necessary: over this bandage fomentation or evaporating lotion may be applied. If inflammation ensue to an alarming extent, and threaten deep suppuration, especially under fasciæ, the puncture is to be converted into an incised wound, sufficiently ample to allow free and early egress to whatever product of the morbid action may be disposed to collect there. When the puncture has penetrated a fascia, the surgeon is to be on his guard not to wait for great swelling and fluctuation ere he uses his bistoury, since all the mischief may have taken place ere it becomes evident by these signs. If pain continue unsubdued, with fever, during three days, there can rarely be any question about the propriety of resorting to the knife. It is not often that counter-openings are necessary where an early vent is afforded to the matter; but where due precautions have not been taken, and the pus has been allowed to burrow far from the seat of its first formation, they are highly useful. Of counter-openings in general, it may be said that they are of service, by giving a freer outlet to discharges, without the serious consequences of laying open the whole of an extensive cavity or sinus. They are usually to be made only where nature already points the way, by bringing the matter near the surface at a distant part, and if there is room for choice, they should occupy a depending position, so that the discharges may drain away as they are formed. Much of what we have now said is applicable to the treatment of stabs. In these injuries, the great vessels are more apt to be divided, and the wound to be distended with blood. (See *Hæmorrhage* in the present article.)

Of lacerated wounds.

*Lacerated* wounds frequently unite in whole or in part by the first intention if their opposite surfaces are carefully kept in contact, and general precautions used; therefore it is an axiom in surgery, at least in this country, that they are to be treated in the first instance as though they would unite, unless there be some evident reason to the contrary, such as the co-existence of severe contusion on the lacerated surface (gun-shot wounds), or the presence of much dirt in the wound that cannot be washed away. This practice is highly rational. It seems certain that there cannot be a better application to a wounded surface than that from which it has just been severed, and whatever fraction of it unites, is so much retrieved from suppuration, while, if the attempt fail, the condition of the wound is no worse than it would have been if the attempt had not been made. Of course in the early stage of lacerated wounds



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Surgery.

the surgeon will look for inflammation, and be prepared to combat its excess.

Treatment of contused wounds.

*Contused* wounds, if uncomplicated, require very simple treatment. The blood effused distends the tissues, and as a considerable depth of substance is commonly implicated, the inflammatory engorgement following the injury is considerable, and adds greatly to the swelling and pain. It is, we suppose, on the principle of diminishing or subduing this, that the practice of bleeding the injured part with leeches is so frequently adopted; the common notion that these animals suck out the effused blood scarcely requires refutation. Warm fomentations and cold lotions are both useful remedies in contusions, but the former seem the more generally appropriate. These act by relaxing the tissues, and allowing them to yield more to the distension, the latter by diminishing the flow of blood to the part, and carrying off the excess of heat. When a large quantity of blood is collected in a cavity under the skin, as a consequence of contusion, it may frequently be absorbed, after the inflammatory action has subsided, under the use of lotions of sal-ammoniac and pressure. If it occasion obstinate inflammation, with tension of the surrounding structures, and sympathetic fever, suppuration is to be feared, and it will be the best practice to lay open the cavity and evacuate the blood. This plan usually gives instantaneous relief.

### Wounds.—Thorax.

Penetrating wounds.

Penetrating wounds of the great cavities of the trunk are so important in their consequences, and so peculiar in their nature and treatment, as to require to be spoken of apart from the general subject of wounds. Their danger springs from two causes: the injury to the lining membrane, and to the vessels or vital organs contained within the cavity. Death may be immediate, or nearly so, from internal hæmorrhage, for which there is rarely any remedy at command; or it may occur at a period more or less advanced, in consequence of inflammation or its results.

Wounds of the Lungs.

Wounds of the lungs are attended with difficult and irregular breathing, hæmorrhage both into the pleural cavity and into the air passages, in different degrees according to circumstances; and with faintness, pallor, and anxiety, and a sense of suffocation. The lung collapses by the escape of air from it into the pleura, and thence externally into the cellular tissue of the body, giving rise to emphysema. If the external orifice in the parietes be large and free, the air enters the pleura from without, and is partly driven out during the expiratory movements. The collapse of the lung is commonly regarded as an unfortunate circumstance in these injuries; but it is in fact one of the most favourable description, as it greatly favours the suppression of hæmorrhage. It is well known that the lungs in a natural state are preserved in a distended condition by the pressure of the atmosphere on their bronchial surface, and that when the pressure on their exterior is allowed in any way to become equalized with that on their interior, they fall into a much smaller compass. Now the blood-vessels of the organ are adapted in abundance and capacity to its natural or distended state; and when this is diminished they have not room to transmit the blood, the size of any wound of them is materially diminished, and its sides are brought together. This is the cause of the salutary effect of collapse of the lung in arresting hæmorrhage from a wound of that viscus. When there exists a communication between the pleural cavity and the external air, either through the walls of the chest or through the lung, as the motions of respiration go on the air is pumped alternately in and out of that cavity, as it is in and out of the lung in the normal state of the parts, and as it may happen that the wound is of a *valvular* nature, so as to allow of the ingress of the air with more facility than its egress, it is possible for the air to accumulate and distend that side of the thorax unnaturally, so as to operate as a mechanical impediment to the movements of the diaphragm, and to push over the mediastinum and its contents to the opposite side, and thus in both these ways to impede the healthy action of the otherwise sound side. This state of things produces an aggravation of all those symptoms that arise from impeded respiration. The surgeon has it in his power to establish a free communication externally by making an opening between the ribs, and thus to take off any unequal pressure the air within may be exerting on the surface of the pleural cavity; and he may even succeed in some cases in pumping out a portion of that contained within by artificially reversing the valvular action at the external orifice and then stopping it by compresses or otherwise. It is almost superfluous to say, that in the wounds of the lungs attended with much hæmorrhage free and copious blood-letting must be practised, and repeated as occasion may demand. This practice is supported by many excellent reasons. It lessens the mass of circulating blood, which it is to be remembered *all* passes through the lungs in each entire circuit of the body, it enfeebles the powers of the circulation, and it tends to ward off and mitigate inflammation. The two last indications have to be pursued by a liberal administration of the emetic tartar, or digitalis; and mercury may be necessary in the sequel.

Wounds of the Heart.

Wounds of the *heart* generally prove fatal, but not instantaneously, as is commonly imagined, unless the orifice be large and inclined to gape. The fact is exceedingly remarkable, that persons who have received thrusts by knives, or other narrow instruments, especially blunt ones, often survive many days, or even several weeks. The reason of their not dying of hæmorrhage seems to be that the muscular fibres of the heart which the wound traverses are disposed in layers oblique to one another, and alter their relative positions at every pulsation of that organ, so that the wound is at once rendered more or less valvular, and only capable of giving vent to the blood within at a particular moment of each beat; and thus that this fluid has time to form a coagulum in the wound soon sufficient to prevent further hæmorrhage. And it may be for the same cause that ultimate recovery is so rare. If not worn out by the constitutional effects of the wound, and the lowering treatment it makes necessary, the movements of the sides of the wound on one another interfere with the subsequent steps of the sanative process by which the temporary coagulum becomes replaced by organized lymph.

The immediate symptoms of a wound of the heart are those of extreme prostration and deadly faintness, whether they are attended with much hæmorrhage or not. The central organ of the circulation being itself struck, that function seems for a time to be paralyzed, the beats of the heart are feeble, irregular, and faltering. This state is highly conducive to the formation of the coagulum which we have spoken of; and is not

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Surgery. Wounds of the Heart.

to be too early or too rapidly counteracted. Re-action is to be cautiously promoted, but checked by bleeding and other measures when it threatens to rise too high. Of the remaining part of the treatment we have little to say, for little is in the power of the surgeon to accomplish; he has but to watch for symptoms and too often with the almost certain dread of the failure of his most judicious endeavors.

Wounds of the Abdomen.

Wounds of the *abdominal cavity* are, if possible, even more serious than those of the lateral cavities of the thorax. Their fatality will however depend on many particular circumstances, of which the nature of this great cavity and its contained viscera affords a large variety. As the viscera are everywhere in the closest contact with the parietes and with one another in consequence of the pressure exerted by the muscular walls, and by the external atmosphere through these, it is rare to find the serous cavity laid open without the viscera participating in the injury. The liver and spleen, being usually concealed under the false ribs, generally escape direct wounds in front; but they may be struck by thrusts through the lower ribs, or through the lower part of the thoracic cavities and diaphragm. Or again, they may be crushed and lacerated by severe blows or concussions of the abdomen, such as those caused by a spent ball, by a cart passing over the trunk, or by a fall of earth; the last of which is a very common accident to our workmen engaged in excavating for railroads, canals, and other public works. Such injuries are usually fatal at once, or after a brief interval of attempted re-action, by hæmorrhage; and the practitioner is unable to render any aid beyond measures of the most general kind: he is indeed ignorant of the extent, position, and precise nature of the injury until death enables him to determine them.

Wounds of the other viscera may be produced by mere contusion, which leaves few or no traces of its effect on the walls of the cavity. Such are in most cases rupture of the hollow organs, often accompanied with an occurrence of fatal moment, viz. the escape of their contents into the peritoneal cavity. The stomach, small or large intestine, the gall-bladder, or the urinary bladder, may thus suffer, and are particularly liable to do so if distended at the time when the violence is inflicted. Their contents seem alike irritating to the serous membrane, and inevitably enkindle in it a mortal inflammation that carries off the sufferer in a few hours or days. Such inflammation is marked by more acute and exquisite pain than attends ordinary peritonitis, and its agonizing character commences suddenly, and from the very first. The abdominal viscera being surrounded by muscles which ever exert considerable pressure upon them, it follows that they are at once protruded through any aperture in the walls sufficiently ample to permit their escape. Protrusion of viscera is a common complication of abdominal wounds. The *Omentum*, from its anatomical position, is the organ most frequently displaced, and after that the small intestines, which both occupy a large space of the cavity, and are very moveable. Protruding omentum is to be returned by careful pressure, care being taken to relax the abdominal muscles by posture, and the wound being dilated, if necessary, by a bistoury. When a knuckle of gut is thrust out at the wound, it in like manner is to be returned, the same precautions being used as would be proper in a case of hernia. In particular, caution is requisite to ensure the real return of the intestine, as if small it may slip between the layers of abdominal muscles, and thus remain protruded and strangulated, although concealed from view.

Surgery. Wounds of the Intestines.

The intestine, however, may be wounded as well as protruded, and then further considerations arise as regards the treatment. It is evident that it ought not to be returned with the wound open, as its contents would almost inevitably escape into the serous cavity. Whether it be returned at all, and what course should be pursued with regard to the wound in it, will depend altogether on the extent and nature of the latter. If all the coats are divided, the mucous membrane is invariably everted, owing to the laxity of its cellular connexion with the muscular, and the contraction of this upon it; if the wound be small, this eversion of the mucous lining appears in the form of a button, filling up the orifice and presenting a bar to extravasation of the contents. To this circumstance is to be assigned the infrequency of large fæculent effusions when there is really a considerable orifice in the side of the canal. In the cases of protruded and wounded intestine which we are considering, if the wound be small, that is, not involving more than a quarter of the circumference of the bowel; the mucous membrane is to be returned within the muscular tunic, and the edges of that and of the serous membrane sewed together with fine thread, the ends of which are to be cut close; after which the whole may be put back loose into the abdomen. The process which now occurs, in favourable circumstances, is as follows: adhesion takes place between the affected part and the serous surface of the neighbouring organs with which it chances to be in contact, and shuts off the wound and its immediate vicinity from the general cavity of the abdomen. The ligature then occasions ulceration of the cavity, loosens and falls into the calibre of the gut, and is then carried along and expelled with the fæces, the wound being gradually united more firmly. If this process fail, it will be by the extension of peritonitis over the general surface of the membrane, the consequent failure of the healthy process of adhesion about the wound and the effusion of the fæculent matters from the intestine into the peritoneum, an event necessarily fatal.

When the intestine is wounded to an extent greater than one-third its diameter, there can be little hesitation in relinquishing all attempts to effect the cure in the way above mentioned, as being attended with too great a chance of failure, and, with failure, of certain death. The only safe treatment now will be to prevent the wounded part from re-entering the abdomen. The intestine is to be returned as far as the orifice in its coats, which are then to be stitched to the borders of the aperture in the parietes. Adhesion follows; and an artificial anus is established, which is to be treated on the same principles as in those sometimes consequent on hernia, to which subject we must refer for further information.

### Gunshot Wounds.

These differ from ordinary wounds, chiefly by the severity of the contusion inflicted on the surrounding parts, leading necessarily to the death of the tissues in the track of the injury; they are usually of a very grave character, either from the extent of parts implicated, from the vital organs affected, or the danger of



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hæmorrhage; and they offer many minor peculiarities, arising out of the various nature of the piece or of the missile, and the circumstances under which they are usually received. The external aspect of the wound, caused by the entry of a ball, is unlike that of any other. It is round, blackened, and with inverted edges, and somewhat smaller than the missile that has passed in, owing to the partial yielding of the elastic skin before the force, and to the tumidity that quickly ensues from the engorgement of the surrounding textures. If the wound be occasioned by the exit of the ball, its edges will be most probably everted, and will appear more ragged from this circumstance. These are conditions which the cautious surgeon will not omit to notice, remembering in these and all other cases, the important rule, to gain all possible acquaintance with his patient's state, by a full examination of his person; a rule doubly necessary in all those injuries which, by their severity, tend to close up other sources of information.

Lodgment of balls.

The lodgment of balls, or any extraneous material that may have been carried before them in their course, such as buttons, coins, accoutrements, or the like, or even fragments from the mutilated bodies of comrades, forms a peculiar complication of gunshot injuries, and one demanding peculiar modes of proceeding on the part of the surgeon. Where it is possible, the finger should be employed to search for such substances, and trace the path they may have taken. Splintered fragments of bone, detached from their vascular connexions, and thereby reduced to the condition of dead extraneous substances, irritating by their deep position and sharp irregular figures, may have been driven into the surrounding soft parts, and may require immediate removal for the avoidance of the ill consequences which their delayed presence would inevitably entail. It is obvious that all such matters are to be removed, if possible, on the first inspection of the injury, and the sooner after its receipt the better; incisions are to be practised for their extraction, which may be done the more boldly, because they will tend to relieve subsequent tension and the lodgment and burrowings of pus, and may often be carried through parts that must necessarily perish by subsequent sloughing.

But it often happens that bullets cannot be traced to their real site, or this may be in the spongy texture of the bones, or in or near the cavity of a joint, buried from view, and out of the reach of any but very sweeping incisions. The most prudent course to be adopted under such circumstances will be to proceed as though they were not present. It will often happen that the progress of inflammation and its consequences will disengage the foreign body at a subsequent period, which the surgeon should be on the watch for, and prepared to accelerate as occasion may arise. And it will not unfrequently occur, especially in the interior of bones, and in such positions among the softer textures as are little exposed to movement, that smooth balls of lead, or other metal not prone to oxidize, will be gradually walled in by a firm cyst of organized lymph, and be thus prevented from irritating.

Course of balls.

The course which balls sometimes take within the body is exceedingly remarkable. "A ball will often strike the thorax or abdomen," says Dr. Hennen,* "and to an inexperienced eye, will appear to have passed directly across, or to be lodged in one of the cavities. If great difficulty in breathing, or hæmorrhage from the mouth, with sudden paleness and laborious pulse, in the one case, or deadly faintness, coldness of the extremities, and the discharge of stercoraceous matter from the wound, in the second, are not present, we shall find that perhaps the ball has coursed along under the integuments, and is marked in its progress either by what Mr. Hunter compares to a blush, or by a wheal, or dusky line, terminated by a tumor; on opening which, it will be easily extracted. In some of these long and circuitous routes of balls, where we have not this mark, a certain emphysematous crackling discovers its course and leads to its detection. The ball is, in many instances, found very close to its point of entrance, having nearly completed the circuit of the body. In a case which occurred to a friend of mine in the Mediterranean, the ball, which struck about the Pomum Adami, was found lying in the very orifice of its entrance, having gone completely round the neck, and being prevented from passing out by the elasticity and toughness of the skin, which confined it to this circular course. This circuitous route is a very frequent occurrence, particularly when balls strike the ribs, or abdominal muscles; for they are turned from the direct line by a very slight resistance indeed, although they will run along a continued surface, as the length of a bone, along a muscle or a fascia, to a very extraordinary distance at times. If there is nothing to check its course, and if its momentum is very great, it is surprising what a variety of parts may be injured by a musket ball. I have seen cases where it has traversed almost the whole extent of the body and extremities. In one instance, which occurred in a soldier, with his arm extended, in the act of endeavouring to climb up a scaling ladder, a ball, which entered about the centre of the humerus, passed along it, over the posterior part of the thorax, coursed along the abdominal muscles, dipped deep through the glutæi, and presented on the fore part of the opposite thigh, about midway down. In another, a ball, which struck the breast, lodged in the scrotum, the man standing erect in the ranks." "In six fatal cases which I very minutely examined, this occasional course on a concave surface was very visible. In two the ball passed between the lungs and pleura costalis, entering on the right of the sternum, coursing round, and passing at nearly an equal distance through the opposite side, near the spine. In one, the ball entered over, and was supposed to have passed through, the spleen. On dissection, it was found to have passed along the posterior part of the spleen, and lodged beside the spine, leaving a furrow all round from its entrance to its lodgment. In one, the ball entered exactly over the spleen, and passed round to the middle of the tenth rib of the right side, furrowing the diaphragm. In two, the balls entered close to the umbilicus, and passed out exactly opposite, beside the spine. The men were supposed to have been shot through the bowels; but it was found that the balls had passed round the abdominal parietes, run between them and the contained viscera, without opening them, and passed out. In all these cases inflammation was present to a very high degree; and, in one, gangrene was so far advanced as to render dissection extremely offensive. A further proof of the propensity of balls to take a curved direction is often seen in cases where

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* *Observations on Military Surgery*, pp. 32—36.

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they strike the front of the hat, and, running round, carry off the hinder tassel."

Hæmorrhage is one of the most common attendants on extensive gunshot injury, and proves almost instantly fatal in by far the greater number of those cases in which any of the larger vessels are wounded. Much, however, will depend on the size of the aperture made in the vessel, and the degree of dragging to which the artery has been subjected, for reasons which the intelligent reader will easily comprehend when he shall have perused our remarks on the general subject of hæmorrhage. In almost all cases blood continues to flow from the wound for a considerable time, and generally this blood is arterial. It never comes from the minute vessels, for these are destroyed by the injury; but unless the hæmorrhage be difficult to check by pressure, and takes place in jets, there will be no proof of a great artery being implicated. Secondary bleeding is more common in gunshot than in any other kind of wounds, on account of the certain sloughing which occurs in the track of the missile, and by which a vessel is exposed that may have been either wounded and the blood temporarily stanched, or destroyed, without being laid open. From these disastrous gushings, whether occurring unexpectedly, in the midst of symptoms otherwise favourable, or after the system has suffered severely from the inflammation, and other consequences of the wound, very many lives have been lost.

The constitutional results which ensue on wounds by gunshot are those of the severest shock, except in cases where the sufferer is armed with unusual fortitude, or has received the injury when under the excitement of conflict. Military surgeons have recorded instances of the most striking nature. "Some men will have a limb carried off, or shattered to pieces, by a cannon ball, without exhibiting the slightest symptoms of mental or corporeal agitation; nay, without being conscious of the occurrence; and when they are, they will coolly argue on the probable result of the injury."* But in general the wounded man is seized with universal tremors, deadly paleness, and cold perspirations, which are not met with of quite the same description in any other kind of injury.

*Treatment of Gunshot Wounds.*—What relates to the treatment applicable to foreign bodies and hæmorrhage has been already discussed. In gunshot wounds received during the movements of an army in the field, the propriety of amputation has frequently to be judged of on grounds somewhat different from those on which its determination would rest under different circumstances. The badness or deficiency of the means of transport, the distance of the hospital, the proximity of the enemy, the number of the sufferers, are all but too potent arguments, drawn from necessity, for the performance of this operation, in order to preserve life. And the nature of these injuries is in itself such as to make amputation more often necessary than in others apparently of equal extent, for the contusion and laceration of the soft parts, and their consequent death, is usually more extensive than at first appears, and great vessels will sometimes give way unexpectedly, which seemed to have escaped injury. The general accuracy of this remark will not be invalidated by the singular instances of recovery under circumstances which had appeared originally the most destitute of hope. Unfortunately, the conditions under which military surgery is practised are often such as not to allow of that accurate discrimination and calm consideration which, in civil life, will be given by the conscientious practitioner to every case in which life or limb are in jeopardy. The operations of the field are performed amid excitement, anxiety, and confusion, and it must ever happen that the result will show some to have been undertaken ill-advisedly, others to have been omitted that might have saved life, while on the other hand some cases will be found to have recovered, without having submitted to an operation which the established rules of experience would have sanctioned and even enforced.

* Hennen, *loc. citat.*, p. 31-2.

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### Hæmorrhage.

As this is a subject of fundamental importance in Surgery, we shall offer no apology for considering it somewhat in detail in this place.

Arterial hæmorrhage.

*Arterial Hæmorrhage.*—The structure of the arteries is admirably contrived, not only to convey the blood propelled by the strokes of the heart into every part of the body, but to resist the violence of external injuries, and thus to screen the system from two of their most dreadful effects, hæmorrhage and gangrene. Every one moderately acquainted with the nature of severe injuries must have been struck with the immunity which the great vessels often enjoy, while surrounding muscles, fasciæ, and bones are torn or broken. And even when a large artery is lacerated, or severed across, as when an entire limb is carried away by a cannon-shot or by machinery, it is wonderful how little hemorrhage ensues, in very many instances.

The arteries consist of a thick tunic of yellow elastic fibres, arranged in a more or less circular manner, lined by a very delicate film of transparent epithelium, and invested by areolar tissue, mingled with minute nutrient vessels, the *vasa vasorum*.

This areolar or cellular tissue forms a sheath, in which the artery runs; it is extensible and elastic, composed of fibres running loosely in all directions, and thus allowing motion of the vessel which it encloses.

The yellow elastic, or proper, or middle coat of arteries, in consequence of the transverse arrangement of its fibres, will easily tear across when the vessel is stretched lengthwise, but the outer or areolar sheath, not being in the least degree brittle, will under the same circumstances be drawn out between the broken ends of the former into a tube, and on at last giving way, will form a conical canal prolonged for some distance, often for nearly an inch beyond the rupture in the middle coat, and coming to a point at its extremity. The blood has now to traverse this canal before it can gush forth externally, and for a very short time it will do so; but on its way it becomes caught in the meshes of the areolar tissue, and coagulates, forming a plug accurately fixed to the extremity of the vessel, and effectually preventing further effusion. The great artery of a limb thus plugged up we have several times seen protruding itself far out of a stump, formed by the dragging off of an arm by machinery, and pulsating strongly and visibly. The physical process on which it depends may be artificially imitated on a dead artery by forcible stretching. This is the most beautiful example of the conservative power which is provided in the construction of the living channels through which the vital fluid is destined to flow, and exhibits it in the most striking point of view. The temporary depression of

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the heart's action, consequent on the shock, is an important aid, both to this and other processes by which hemorrhage is naturally stayed.

When an artery of moderate size is divided by a sharp instrument, there is usually more blood lost than in the lacerated wound just described. We are indebted to Dr. Jones, and since him to several other authors, for researches into the means which nature employs to restrain this hæmorrhage. "An impetuous flow of blood, a sudden and forcible retraction of the artery within its sheath, and a slight contraction of its extremity, are the immediate and almost simultaneous effects of its division. The natural impulse, however, with which the blood is driven on, in some measure counteracts the retraction, and resists the contraction of the artery. The blood is effused into the cellular substance, between the artery and its sheath, and passing through that canal of the sheath which had been formed by the retraction of the artery, flows freely externally, or is extravasated into the surrounding cellular membrane, in proportion to the open or confined state of the wound. The retracting artery leaves the internal surface of the sheath uneven, by lacerating or stretching the cellular fibres that connected them. These fibres entangle the blood as it flows, and thus the foundation is laid for the formation of a coagulum at the mouth of the artery, and which appears to be completed by the blood as it passes through this canal of the sheath, gradually adhering and coagulating around its internal surface till it completely fills it up from the circumference to the centre.*

"It appears, then," says Mr. Samuel Cooper,† "that a coagulum, which Dr. Jones calls the *external* one situated at the mouth of the artery, and within its sheath, forms the first complete obstacle to the continuance of bleeding; and though it seems externally like a continuation of the artery, yet, on slitting open this vessel, its termination can be plainly observed, with the coagulum shutting up its mouth, and contained in its sheath.

"No collateral branch being very near the impervious mouth of the artery, the blood just within it is at rest, and usually forms a slender conical coagulum, which neither fills up the canal of the artery, nor adheres to its sides, except by a small portion of the circumference of its base, near the extremity of the vessel. This coagulum is distinct from the former, and what Dr. Jones calls the *internal* one."

The processes now adverted to are attended with but a temporary suppression of the hæmorrhage; for the permanent obliteration of the vessel at the wounded point, other and less mechanical operations are demanded. In the former case there will be great danger of a recurrence of the hæmorrhage, when the extremity of the vessel and the newly formed coagulum shall slough, as they almost inevitably will do, when so much isolated from other structures; and if art do not interfere, the result will in all probability be fatal. In the latter case, the inflammation that occurs in the wound will be attended by an effusion of lymph from its entire surface, including the cut extremity of the vessel and the vasa vasorum of the sheath within which it has retracted. This lymph mingles with the coagula already mentioned, and becomes consolidated with them, sealing up the orifice and uniting it and the sheath to the surrounding structures, so that even if the general surface of the wound should assume the suppurative inflammation, the vessel will under ordinary circumstances be closed up from the external wound. Coincidently with this process, a slow contraction takes place in the coats of the vessels for some distance upwards, generally as far as the nearest branch. The coagula, too, are finally absorbed, and the extremity of the artery, being now entirely disused, becomes reduced to a firm ligamentous cord, blended with the surrounding structures.

When an artery is only partially divided, as for example, by a transverse incision through one-half of its extent, the tendency of its coats to contract will convert this slit into a gaping orifice, through which the blood gushes without the possibility of the aperture being closed by those natural processes either of temporary or permanent suppression, which have been described. Hence these wounds are of extreme danger, when the vessel implicated is considerable. If the transverse wound involve only one fourth, or less, of the circumference, there is a possibility of the coagulum formed on its exterior among the cellular texture, being sufficient to close it, and to prepare the way for the permanent closure by lymph.

Such is a brief sketch of the natural means by which hæmorrhage is capable of being arrested, and which were necessary to be comprehended before the surgical proceedings put in practice for the same object could be understood. Much more might have been added, if it had been consistent with the scope of the present article.

These means, if left to themselves, are but too often lamentably insufficient, and it becomes the surgeon's duty to step in, and, by his knowledge of what is most essential in the natural processes, to conform the circumstances of particular cases so that the desired result, the permanent obliteration of the vessel at the wounded point, may ensue. It will often happen, if the artery be small, that pressure judiciously applied will entirely command the flow of blood until a coagulum is formed, and the first steps of the adhesive process are completed, after which no other measure will be necessary beyond repose of the part, and of the system. It is constantly necessary to apply pressure in the first instance to all kinds of external hæmorrhage,—but in many instances it serves only the momentary purpose of gaining time until more effectual means can be adopted. Pressure must always be applied, if possible, to the bleeding point itself, and if the alarm of the moment would allow the by-standers to do this, even in cases of severe hæmorrhage, many lives would be rescued. But it too often happens that the sight of blood bathing the clothes about the wound prevents this obvious measure from being carried into effect, as common sense would direct. Handkerchiefs, towels, anything that is at hand is thrust over the orifice, without method or discrimination, as though to conceal the progress of the mischief from the eye were to offer an effectual check to it. It can scarcely be too strongly impressed upon persons in general, but particularly upon soldiers, and others who are liable to be called on to give instant aid in such circumstances, that very slight pressure will be sufficient to restrain the most alarming hemorrhage, if it be but applied to the right spot, that is, to the bleeding point. Pressure on the vessel above the situation of the injury, either by the finger or a

* Jones *On Hæmorrhage*, p. 53. † *Surgical Dictionary*, p. 627.

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Arterial hæmorrhage.

ring tourniquet, is the other obvious mode of temporarily arresting the flow of blood. If the tourniquet be employed, care must be taken that it be not so tight upon the limb as to cause the parts below to become turgid with blood, the consequence of which, if long continued, might be gangrene.

The ligature.

But where blood continues to start in jets from a wounded vessel of any size, there is but one course which will remove anxiety from the surgeon's mind, by the almost invariable certainty of its success, and that is the *ligature*. It is exceedingly remarkable that the ancients, who were acute observers of the effects of injury and disease, and ingenious in devising remedies for them, should have failed to practise this apparently obvious device; but it must be remembered that they were under the trammels of false views of the nature of the arteries, and were entirely ignorant of the circulation of the blood. The ligature appears to have been employed by Celsus, but from the fact of its having been entirely relinquished till the days of the great Paré, the surgeon of Henri Quatre, who revived it, its advantages must have been very imperfectly appreciated, and its application very limited, in the days of the Roman author.

Its effects on the arterial coats.

When a thread is tied round an artery, the inner and middle coats are cut through by it, while the outer coat of areolar tissue, by its toughness, resists division even by the tightest pull upon the ligature. The immediate effect is of course a puckering up of the former coats, and an apposition of their cut surfaces within the vessel, which is completely closed at the same time. Then follows the process called adhesive inflammation in the immediate situation of the ligature, the vasa vasorum pour out lymph, which envelopes the parts exposed, and becomes gradually organized and consolidated, not only around the termination of the vessel, but between the cut surfaces of the inner and middle coats within it; where a coagulum is also usually formed, extending to the nearest branch above, and more or less adherent to the lining membrane, according to the extent of the inflammation that has taken place. Meanwhile the outer coat that has been included within the loop of the ligature sloughs, gives way, and allows the thread to escape at a period varying from a week to twenty or even forty days, according to the size of the artery and other circumstances. Thus the ligature performs the part of a temporary plug, until the process of permanent obliteration is sufficiently advanced to secure the patient from a recurrence of the hæmorrhage.

Subsequent processes.

The introduction of the ligature must ever rank as one of the greatest steps in the advance of pure surgery, and the name of Paré will be remembered in connexion with this simple contrivance, long after his other claims to the gratitude of posterity shall have been forgotten. In the present day, when life is daily rescued by its employment, and the disastrous results of uncontrolled hæmorrhage are but seldom witnessed, its value can only be estimated by him who will take the trouble to acquaint himself with the condition of surgery before the days of Paré. Severe, and even trifling, operations could not be undertaken without resort to red-hot knives and other expedients, no less horrible than ineffectual, and which, while they brought the greatest discredit on surgery, most seriously restricted its usefulness. In those days disease and injury must have committed ravages among mankind which, happily for humanity, are now no longer possible in countries where surgery is practised and understood.

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The ligature, however, is not, under all circumstances, a perfect safeguard against a return of hæmorrhage. It is only an aid to certain natural processes, which may fail from many causes alien to the remedy employed. The adhesive process may be supplanted by the suppurative or the sloughing, and then of course the blood will eventually burst out. This leads us to certain precautions in the employment of the ligature, in which British Surgery may claim great merit. The ligature should not be very broad, or it cannot be tied upon the vessel in an even manner, and its office is imperfectly performed. The best thread for ordinary use is common unbleached sewing thread, or silk of corresponding thickness. It is very important that the ligature should be applied close to the healthy part of the sheath, for otherwise this structure and the artery will be apt to slough above the point of deligation. When an artery is divided in a wound it is indispensable that both orifices should be secured by the ligature, even though both do not bleed, for that further from the heart may give vent to blood carried into the vessel below the wound through collateral channels.

Failure of the reparative processes.

The consequences of failure in the process of reparation of a wounded artery are of the most serious kind, even when they do not prove immediately fatal. Secondary hæmorrhage recurs repeatedly, and debilitates the system: the blood is infiltrated extensively among the various textures of the limb, under the fasciæ, and between the muscles; and under these circumstances inflammation of a diffused kind coming on, the patient sinks unless amputation rescue him by the sacrifice of the member. When the textures of a limb are thus gorged with blood, instead of inflammation, or joined with it, there may be gangrene of the parts below, brought on by the diminished or interrupted supply of blood through the main channel, and the general engorgement,—a most unfortunate state of things, which usually proves irreparable. But another set of consequences may arise if the wound in the artery, or in the surrounding textures be small, so that the escape of blood in great quantities is hindered. A cavity, or false aneurism, may gradually be formed among the neighbouring structures by the blood rushing from the orifice of the vessel. The walls of this aneurism may consist of various textures, muscles, fasciæ, or the like, agglutinated by lymph, and its inner surface is ordinarily coated by a layer of fibrine, deposited from the fluid blood that washes its interior. The most common situation for such an aneurism to be formed is at the bend of the elbow, where the artery is occasionally punctured by an unskilful venæsector; but they may occur in almost any situation along the course of arteries of medium size. For further observations respecting them we must refer to the subject of aneurism, shortly discussed in the present article.

It is a rule of primary importance in surgery, that a wounded artery should be secured by ligature at the earliest possible period after the reception of the injury. The reasonableness of this course is too obvious to need further enforcement; the consequences of negligence or timidity in its application are sufficiently disastrous to warn every surgeon against a neglect of it. But yet the individual cases which actual practice presents are so varied in their attendant circumstances that it is not wonderful that the rule has not an unlimited applica-

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tion, and a discriminating judgment will find abundant exercise in determining on the course to be pursued. The sudden deligation of the main artery of a limb is itself an operation which may entail the gravest consequences on the patient. Even if performed before the rush of blood has gorged the interstices of the limb, it has been known to be followed by mortification, and though this do not ensue there are other consequences scarcely less serious, from which the patient cannot be said to be safe until the ligature has separated. Now, although these untoward results are rare, compared with those in general attending the opposite course, yet they constitute a very strong objection to the employment of the ligature, wherever there is good ground to hope that milder measures may prove effectual for the repression of hæmorrhage, by the healing of the wound in the artery, without a permanent obliteration of its cavity at the point wounded. Now such hopes may often be fairly entertained in venæsection wounds, which are commonly small oblique or longitudinal punctures, are easily at the command of pressure, and are inflicted when suitable aid is at hand. In these, and similar cases, strong pressure should at once be made on the bleeding point to restrain the hæmorrhage; the whole limb from the terminal extremity should then be moderately, but uniformly compressed by a bandage, with a graduated pad on the seat of injury. After this, perfect quietude in the recumbent posture, and abstinence from every excitement should be strictly enjoined, and the progress of the case narrowly watched. Cold may be added to the above measures, if it should seem expedient, but the judicious attendant will be ready to remit this or other means, if the circulation should seem too much interfered with.

When an artery has been severed at the bottom of a deep wound, as when a sword has pierced the muscular part of the thigh, and its point touched the artery, it may be a question what course should be adopted to secure the vessel. Two might be attempted:—the one either to follow the original wound by enlarging it sufficiently to expose the bleeding vessel, the other to make an incision altogether new, as near as may be guessed to the injured point, and there taking up the artery. The former is attended with the disadvantage of an extensive division of structures, the latter with that of doubtfulness as to the position of the wound, and the necessity there might be of laying the artery extensively bare before the wound in it could be detected and secured: for to secure it above and below the wound is very important, as a safeguard against a recurrence of the hæmorrhage. Under these circumstances the best alternative is but a choice among evils. It is here that an accurate and practical acquaintance with anatomy has room to display itself, and without it the surgeon is not prepared for one of the most frightful emergencies which the practice of his profession can present. In general it will be better to endeavour to follow the original wound, even at great apparent disadvantage, especially if it continue to bleed.

But it will not unfrequently be found, even in the hands of the best surgeons, that it is utterly impracticable to secure the vessel at the point wounded, and this may arise either from the peculiar relations of the artery at that part, or from the surrounding structures having been spoiled and altered by the extravasation of blood. It will then become necessary to take up the vessel at a higher point of its course, and to trust to this measure for so far diminishing the impetus of the blood, as to allow the formation of a coagulum at the bleeding orifice.

Secondary hæmorrhage.

Hæmorrhage recurring at an interval after the first bleeding from a wound is termed *secondary*. There are certain periods at which it is more apt to come on, such as on the re-establishment of the circulation after fainting, in that state called re-action; or subsequently, when blood becomes determined to the part by inflammatory action; or, again, when ulceration or sloughing of the wound and of the orifice of the vessel occurs, after a coagulum has formed, and the reparative process by lymph has, perhaps, advanced to some extent. At the first and second mentioned periods the treatment will be that which has been already specified, the artery must, if possible, be secured both above and below the wound; but in the latter forms there is much less chance of any attempt to do so being attended by success. Nevertheless if the wound be an open one, and the bleeding orifice in sight, an attempt may be made to pass a thread around it, by carrying it on a needle through the neighbouring textures at some little distance, so as to enclose some cellular tissue along with the vessel, which will not only enable the ligature to retain a firmer hold, but will be more sure of effectually including the entire vessel, now obscured by the changed colour and texture of the surface of the wound. If this prove unsuccessful, the only resource will be either to tie the vessel at a higher point, or to amputate the limb: of these the former is of course to be preferred. Such is the practice which it has been found advisable to pursue in cases of secondary hemorrhage from stumps which have taken on a sloughy character; and in some instances recorded by Mr. Liston, as well as in others that have come within our knowledge, it has been attended with a successful result. Before resorting to so severe a remedy, however, it is needless to say that compression and cold should be tried.

The actual and potential cautery are severe and rough instruments for the suppression of hemorrhage, and now seldom employed, but they are the surgeon's last resource in certain cases of difficulty and danger. The occasions usually demanding them are those in which it is impossible either to encircle the bleeding vessel by a ligature, or to command it by pressure; as for example in the extirpation of fungous growths from the facial bones, in operations for aneurism by anastomosis, and in general where there is an obstinate effusion of blood from a surface rather than from a few separate points. The actual cautery consists of a heated piece of metal, variously shaped to suit particular cases. Most of the instruments of this description displayed in the older works on surgery seem more to belong to farriery than to surgery, and are now deservedly discarded from use. The actual cautery, though still employed by some for the formation of issues, &c., is in by far the majority of instances superseded by the potential. Caustics are used for issues, for destroying unsound parts which have no disposition to repair themselves, such as the borders and surface of certain callous and intractable ulcers, the cysts of tumors, &c. They are likewise of advantage in the opening of certain deep-seated collections of matter, as will be afterwards alluded to.

*Hæmorrhagic Temperament.*—We may here briefly notice a remarkable proneness to hæmorrhage on slight injuries which manifests itself in certain persons, often

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Surgery. Hæmorrhage.

of the same family. A skin or flesh wound, or the removal of a tooth, is followed by a continued bleeding, which neither pressure on the part, ligature of particular vessels either in the wound or leading to it, or the cauterization of the bleeding surface, are able permanently to suppress. It returns after temporary restraint by any of these means, and gradually exhausts the patient. If he with difficulty recovers from two or three such wounds, the next one which he accidently receives proves fatal. There is nothing satisfactory known as to the cause of this singular defect in the natural powers of reparation; but it has been conjectured to be due to some deficiency in the contractile power of the arteries. In a case which we had the opportunity of inspecting, we found their coats somewhat thinner than usual. The blood appears to coagulate as in other persons. In the subjects of this temperament, there is nothing by which they could be distinguished from individuals in perfect health.

Venous hæmorrhage.

*Venous Hæmorrhage.*—This is distinguished from arterial hæmorrhage by the dark purple colour of the blood, and by its equable flow. It is seldom that it proves serious, since it is in general easily checked by moderate pressure on the part. Thus in the bleeding from a varicose vein, the slightest compression by a pad and bandage, joined with the horizontal position, will prevent further effusion, and in the ordinary process of venæsection. But when deeply-seated veins bleed either from a bursting of their coats, or from a wound, it is sometimes difficult to apply pressure. In violent Epistaxis it is sometimes necessary to plug tightly both the front and back apertures of the meatus, which is done by passing a double thread from the nose into the mouth, drawing a dossil then attached to it up against the orifice of the posterior nares, and afterwards tying the ends of the thread over another plug inserted into the nostril. Or again, in hæmorrhage from the tortuous prostatic plexus of veins wounded in the operation for stone in old persons, it is sometimes a matter of extreme difficulty to restrain the flow; and nothing will succeed but firm plugging of the deeper part of the wound; the plug being pierced by a tube for carrying off the urine from the bladder, and for counteracting its tendency to extravasate into the surrounding cellular tissue.

A rupture or wound of the principal vein of a limb is one of the most grave complications that can attend a compound fracture or other injury, and in itself is an accident of a very serious kind, often proving fatal. A sudden obstruction to the flow of blood through such a vein as the femoral is almost necessarily followed by gangrene of the limb below, although the great veins may be obstructed to a wonderful extent in a more gradual manner, without any severe consequence of this description. But the venous circulation of a limb cannot so speedily accommodate itself to a sudden change of route as the arterial, which is conducted in canals of a more extensible and elastic material, and is urged by a greater force. The wounds of veins are attended with a peculiar danger, in the suppurative inflammation that is prone to ensue within the vessel, and this danger is rather increased than diminished by placing a ligature upon them, because this acts as a source of irritation in immediate contact with them during the period that elapses ere the sloughing process allows the thread to separate. The symptoms and effects of Phlebitis belong to another part of our subject.

Surgery. Injuries to the scalp.

*Injuries to the Head.*—By the term Head, in surgery, is commonly meant the cranium, as distinguished from the face. This is a part particularly exposed to injuries of various kinds, and which, from the proximity of the nervous centre, are peculiarly dangerous. The bony vault of the cranium is admirably suited to ward off the effects of violence by its subglobular figure, and by the presence and disposition of its sutures. Owing to this, wounds confined to the scalp or soft coverings of the cranium form a very large proportion of the injuries received on this portion of the body. The structure and vascular connexions of these coverings, however, render them liable to consequences which do not ensue on wounds in other situations. The occipito-frontalis muscles, with their intervening aponeurotic expansion, constitute a kind of skullcap, which is freely moveable on the bone, through the medium of an exceedingly lax and delicate areolar tissue, containing many vessels. This tissue adheres to the periosteum, which itself rests upon the bone. The vessels of the periosteum dip into the bone at innumerable points, and through the diploë inosculate with those of the dura mater, or fibrous investment of the brain, which lines the interior of the cranial cavity. Wounds of the scalp not penetrating the cranial aponeurosis are in no respect peculiar; but if they enter the subaponeurotic tissue, the effusions consequent on them are exceedingly apt to spread mechanically underneath the aponeurosis, instead of escaping at the orifice. The result of this, when these fluids are of an irritating nature, is a rapid extension of inflammatory action over the head, which in its turn augments the amount of the offending material. This may take place in the course of a short time over the entire surface covered by the aponeurosis, and will be known by extreme tenderness, and a deep pitting on pressure, the infiltration often distending the tissue to the depth of an inch. The fluid at first deposited is serum, but if allowed to remain may quickly be exchanged for pus. The subsequent steps will, in many cases, be the formation of sloughs of the cranial aponeurosis, of the surcharged areolar tissue, and of the pericranium itself in more or less of its extent, with exfoliations of the corresponding surfaces of bone: or this frightful mischief may go so far as to reach the interior of the skull by a continuity of the inflammatory action through the bone. In this case patches of lymph may be deposited on the surface of the brain, with a fatal involvement of that organ itself in the consequences of an injury that originally may have appeared trivial.

To avoid these untoward events, everything calculated to lead the inflammation beyond the adhesive stage is to be sedulously avoided or counteracted; all foreign particles are if possible to be at once removed, a brisk purge of calomel administered, and the patient placed upon a strict regimen. If the wound appear indisposed to unite at once, if gravel or dirt cannot be entirely removed from its surfaces, it should be covered with a mild poultice, and left open. And if there should seem to be a tendency to spreading inflammation, with accumulation of fluids, a free exit should be provided for these by free incisions through the aponeurosis. The constitutional symptoms that accompany this wide-spreading inflammation so near the central organ of the nervous system are those of inflammatory fever, and will be complicated in various degrees with others arising from the participation of the



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Surgery.

brain, or its membranes, in the progress of the morbid action.

Concussion of the brain.

*Concussion*.—Among the injuries implicating the brain itself, the foremost demanding attention in a systematic review is *concussion*. This is familiarly known as "stunning," or "taking away the senses." The symptoms instantaneously follow the infliction of the violence, and consist in a suspension of all the mental faculties, including consciousness. On their restoration the patient cannot recall what happened when the injury was received, and is in utter ignorance of all that has occurred during the subsequent interval. The state resembles a deep sleep, from which in most cases he may be roused, but instantaneously relapses. The heart's action is greatly depressed, the pulse is small, unequal, variable; the surface of the body is cold and bedewed with perspiration. The power of voluntary motion is to a great degree lost, but this symptom is liable to vary, and the limbs are often affected with slight irregular twitchings; the irides partake of this condition, and cause the pupils to alter in size and shape. The sphincters are relaxed.

When the symptoms we have now enumerated are well marked, and continue some hours before subsiding, and especially if they show no disposition to subside, it is to be feared that more severe and disorganizing mischief is present; that the brain is lacerated, that blood is effused over its surface, or that the base of the skull is fractured. Vomiting is a most important symptom in these cases, as it mostly indicates severe injury to the brain. Mere concussion, without perceptible organic injury, is very rarely fatal, and on this account little is positively known of its nature or the manner in which it acts in producing the symptoms. But that it is not necessarily attended with rupture of vessels, or with any change in the contexture of the nervous substance visible to the naked eye, is well proved by *post mortem* observation, as well as by the speedy return of consciousness in ordinary slight cases. It is, however, easy to comprehend how a sudden jar transmitted through so soft, so delicately organized a structure as the brain should be attended with so complete and sudden an unseating of its powers. The modern researches of anatomists into minute nervous structure, if they have failed in demonstrating the manner in which it executes its wonderful functions, have at least enabled us more easily to conceive what might be the effects of a rude concussion propagated through it from its osseous case. The primitive tubules of the nerves are composed of an outer envelope of excessive tenuity, within which is a substance exceedingly prone to collect into globules, instead of forming an even stratum within the tube, as it does in a state of integrity. The slightest violence done to the tubes causes them to assume this *varicose* condition, as it has been termed, and the imagination readily conceives that it might naturally be induced by a vehement concussion in the living body, though it is a point that can hardly admit of demonstration to the senses.

The memory sometimes undergoes an extraordinary change from the effects of concussion, of which the following instance is mentioned by Sir Astley Cooper (Lectures, p. 117), as related to him by Mr. Cline. "A man was taken to Guy's, in a state of insensibility, in which condition he remained for some time, but at length recovered; and when he did so, no person in the hospital could understand his language; a milk-woman happening to go into the ward one day, heard him, and discovered that he was speaking Welsh; he told her that he knew English perfectly well before the accident, but after it all knowledge of that language was obliterated from his mind. It had been recently acquired, the impression was less strong, and consequently the more easily effaced."

Surgery.

Concussion of the brain.

"I witnessed a similar circumstance," continues Sir Astley, "in the case of a German, who was a sugar-baker in this town, and who had compression of the brain, arising not from any injury by violence, but from pressure in consequence of the formation of matter. This man could speak English extremely well before the compression; but as the compression increased from the accumulation of matter, he lost his English entirely, and I could only communicate with the medium of an interpreter. At last he lost the power of speaking, even in his native language, and he died in consequence of the accumulation of matter. It is curious to observe the gradual change which takes place in the intellectual faculties, as alterations occur in the brain; and the gradual diminution of ideas which have been more recently acquired, until at length they become totally obliterated. Old persons are observed to be fond of relating anecdotes of their youth, forgetting incidents of more recent occurrence; and the change which takes place in the intellect from injuries of the brain is very similar to the effects of age. The patient becomes, as it were, suddenly old, loses impressions of a recent date, and is sensible only of those which he has received in his earlier years. Such is the state of mind very frequently produced by compression of the brain."

Compression of the brain.

*Compression*.—The symptoms to which *compression* of the cerebral organ gives rise are sufficiently peculiar to make their discrimination a matter, in general, of little difficulty. They consist of stupor, more or less complete, with slow and loud breathing, slow and full pulse, and dilated pupils. The patient can be roused imperfectly by strong impressions on any of the senses, but immediately relapses into unconsciousness. There is some power of muscular motion, evinced by transient struggles, and half-uttered moanings when he is disturbed. The state altogether much resembles a deep sleep. The symptoms of compression may supervene at once, if they depend on a displacement of bone inwards in the direction of the brain, and they may be instantaneously removed by its restoration to its proper place. But compression is often occasioned by an effusion of blood forming a clot either among the membranes, or within the cerebral substance; and then its symptoms approach gradually, at a distinct interval after the injury, corresponding to the slow escape of the blood from the wounded vessel. Or at a period long subsequent, when inflammation has had time to complete its effects, compression may be the result of a deposit of pus in some situation within the cranium, where injury may have been sustained.

In severe injuries to the head it very frequently happens that the indications of the nature and extent of the mischief are rendered obscure by the complication and varying intermixture of the above symptoms in the same case, and if there be no external mark sufficient to direct his judgment, the surgeon is compelled to confine himself to general measures of relief, and to await the development of more distinctive signs.

*Fracture*.—These vary much in themselves, and

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Surgery. Fracture of the skull. Cracks or fissures.

even more in their complications and general effects in different cases. *Cracks* or *fissures* are usually extensive when they occur alone, and commonly prove fatal by the internal disorganization that accompanies them. They are occasioned by obtuse blows, as by falls from a great height; the violence must be very great in order to produce them, and this is the cause of the frequency with which they are conjoined with severe lacerations of the cerebral substance, and with large extravasations of blood. All this amount of injury frequently occurs without anything on the surface to point out the seat or existence of such an injury, and it can only be surmised. Bleeding from the ears or nose is a common symptom of a fissure running through the base of the Skull, and it may be suspected in cases where the symptoms of laceration are present. When a fissure crosses the course of one of the venous sinuses, as of the lateral sinus, this canal may be ruptured and pour out a large quantity of blood; and a similar thing may happen when the great meningeal artery is implicated. Fissures usually take a more or less transverse direction, and run across sutures as though the whole vault were a continuous piece.

Starred fractures.

*Starred fractures* are the effect of great violence applied to a small part of the surface; the force is more spent upon the bone at one spot, and the internal hurt is commonly less severe. These fractures may be classed with several other varieties as local fractures. Their particular nature will differ with the kind of instrument which inflicted them, with the protective covering worn, and other circumstances too numerous to be specified. These local fractures are those so often attended with depression, and in which the aid of surgery can be most effectively employed. When the depression is obvious and the principal cause of the symptoms, the early elevation of the piece will speedily remove the most urgent of them, and frequently be the undoubted means of saving the patient's life. From the very common conjunction of the complications already spoken of, and from the further fact of even local mischief that an operation might remedy being obscured by the unbroken state of the soft coverings of the Skull, the surgeon's course is continually beset with difficulties in these unfortunate cases. In circumstances apparently hopeless it will sometimes be his duty to proceed with an explorative operation, which the result may prove to have been, in its very nature, utterly useless. But it becomes him on no occasion to refuse the possible resources of his art to a suffering fellow-creature, from a dread lest the result, if untoward, may bring discredit on himself or the operation.

With depression of bone.

If there exist a compound fracture with depression of bone or fragments driven in upon the brain, the course to be pursued is plain. The displaced pieces are to be raised, and if isolated, or nearly so, they are to be removed altogether. Loose pieces are sometimes thrust between the bone and the dura mater, and admit of removal with ordinary forceps; but in general special means have to be resorted to for the elevation of sunken bone. A lever has to be insinuated beneath them to prise them up. If there be an aperture already large enough to admit this instrument, it may be introduced, and the piece raised by making a fulcrum of the sound bone at its border; if no opening sufficiently large have been made by the injury, it is requisite that the surgeon should make one. In this consists the operation of trepanning or trephining, as it now ordinarily denominated. The trephine is a circular saw, of a size varying from that of a sixpence to that of a shilling, with a projecting centre pin, removable at pleasure. The patient being conveniently laid with his head on a firm pillow, and the integuments turned aside from over the seat of fracture, the instrument is to be placed just so far on the border of the sound bone that the centre pin may be planted upon it. It is then to be rotated backwards and forwards, by quick motions of the fore arm, until the saw has made its way into the surface of the bone. The centre-pin is now to be removed and the rest of the perforation to be completed by the saw, a probe being introduced into its track from time to time, and great care being taken that it do not penetrate beyond the inner table. A narrow lever will now be sufficient to loosen and extract it, and the subsequent steps of the operation will consist in the removal of all detached fragments, and the elevation of such as are bent in upon the brain. If any spiculæ project across the opening they are to be carefully removed, and for this and other purposes, the small saws, named after Mr. Hey, will be found of essential service. The flaps of integument have then to be brought together over the aperture, and a light compress and bandage applied. If it can be avoided, the trephine should not be applied over the course of the longitudinal sinus, or of the middle meningeal artery, as these vessels, and especially the latter, may be torn by the saw, in consequence of their lying in grooves on the inner surface of the skull.

Surgery. Trephining.

In some instances the existence of a depression of bone can be detected by the fingers, even though the integuments are themselves untorn. The discrimination, however, is liable to be obscured by effusions of blood into the sub-aponeurotic areolar tissue of the scalp, which, pitting on pressure, may even give a feeling of sunken bone, particularly if sufficient time has elapsed to allow of the walling in of the ecchymosis by lymph. But even if there be no doubt of the existence of a slight depression, this may be nothing more than an indentation of the outer table upon the diploë, while the inner, compact, and hard table of the Skull has altogether escaped injury. This, however, can only occur in adults of middle age, as the diploë does not exist either in children or in old persons. The treatment under these circumstances will be determined more by the cerebral symptoms than by the external conditions. If compression be evidently present no doubt can exist as to the propriety of the surgeon's cutting down on the suspected part to explore the bone. If he find depression he will proceed to trephine and raise the bone; if there be merely a fissure, he should yet trephine, as the inner table may be depressed though the outer is not, and especially in the hope of meeting with a clot of blood between the bone and dura mater, which may admit of extraction through his opening. Mr. Abernethy even advocated a still bolder procedure in case this external clot were not found, and the dura mater had a dark hue and bulged up into the wound: we allude to his proposal to cut into this membrane in expectation of discovering the sanguineous effusion in the arachnoid cavity. In several instances this has been actually effected, and the sufferer's life thereby saved, but it is comparatively a rare lesion, and when it does occur, the blood but too often spreads over the hemisphere, or diffuses itself at the base of the Skull, and is besides in too great quan-

Surgery. Fracture of the skull.

tity to be effectually expelled through a small orifice. It need scarcely be added that this plan of puncturing the dura mater, if adopted, greatly diminishes the chance of eventual recovery from the penetrating wound which the adventurous surgeon has already made through the principal protective covering of the brain. But, if the cerebral symptoms have subsided, or are in rapid progress towards amendment, it will be prudent to abstain from making a new wound, and converting a simple fracture (if one exist) into a compound one; for, in addition to the uncertainty already mentioned as to the real existence of depression, it is abundantly proved that the brain will permanently accommodate itself to considerable depressions, even to those of a quarter of an inch, if the early dangers of inflammation be avoided. Where a slight depression of bone is permitted to remain, double attention, if possible, should be paid to the future progress of the case; and for a long period subsequently, and indeed for life, a strict abstinence from all causes of excitement should be enjoined. The lurking danger of irritation being lighted up at any after-time, by any casual excess or constitutional bent, must certainly be admitted as a strong argument against leaving a portion of bone depressed upon the brain, under circumstances at all favourable to its immediate elevation. But where the probability of permanent recovery without it is so well substantiated, the surgeon can have no right to tamper dangerously with his trephine from the dread of distant and uncertain evils.

As in the treatment of all other wounds, it becomes necessary, after the first manual adjustments are performed, to watch the progress of the local and constitutional symptoms, with a view of adapting measures of alleviation to them as they arise. Inflammation is the great and formidable enemy to be dreaded, and is to be combated by the most active remedies, as its spread among the membranes or in the cerebral substance would be attended with fatal consequences. We must confine ourselves to a very summary account of the symptoms likely to ensue on severe injuries of the brain or its covering, and of the treatment they will require, because they are in general similar to those of spontaneous disease involving the same parts, and have been considered under another head (see MEDICINE). During the first days the indications of the pulse must be accurately studied, together with the marks of febrile disturbance, and the state of the cerebral functions. Bleeding, both general and topical, will in general be found necessary and proper to be repeated. Calomel purges and enemata are to be administered, and mercurials or tartar emetic may be given so as to affect the constitution. The better acquaintance the surgeon possesses with the nature and signs of cerebral disease, and of its secondary effects on other organs, as the heart, lungs, and digestive tube, the better will he be able to adapt his remedies with prudence and vigour, as occasion may demand. For in no cases, perhaps, in the whole range of his profession, will acuteness and knowledge be more wanted to enable him to diagnosticate with judgment, than amid the ever-varying complications he will meet with in the after-treatment of severe injuries of the brain.

Patients may die during the inflammatory process immediately following the injury, and they are especially liable to do so if the cerebral substance itself have suffered laceration; for this latter hurt is necessarily followed by an increased afflux of blood to the part, and does not usually occur without a great and general commotion of the nervous matter. The lacerated part is then found pulpy, grumous, and disorganized, and the neighbouring structure discoloured with blood, both gorging its vessels and extravasated in the form of minute ecchymoses; while the membranes in the vicinity contain more blood than natural, and are more or less bathed in inflammatory exudations. If, by treatment or otherwise, the acute stage of inflammation be overpast, and the symptoms appear to have abated, or even not to have come on at all, too much confidence as to the issue must not be indulged in; for it is but too certain that the most disastrous results from these injuries are sometimes the most insidious in their mode of access. After a longer or shorter period of deceitful suspense, incoherence or sudden palsy may supervene, followed by symptoms of cerebral excitement, quickly merging in those of compression, which prove speedily fatal. On examination there is found in some part of the brain that has probably received injury when the violence was inflicted, a large collection of pus imperfectly walled in by soft vascular membrane, and the surrounding brain red and diffluent from recent inflammation,—the explanation of all which phenomena is as follows: the surrounding brain has for a time accommodated itself to the presence of a local purulent degeneration, and the activity of the first inflammation has subsided, but after the temporary lull thus caused, the pressure of the augmenting abscess has at length lighted up inflammation around, giving rise to the sudden attack and fatal consequence. It is important to note that all this train of symptoms, connected with the same condition of parts, may originate in an external injury apparently slight, and from which the patient may seem to have completely recovered. This happens, perhaps, in some instances in consequence of some predisposing cause lurking in the system previously to the injury, and which this has but served to call forth into active operation. But however that may be, the fact is one which should lead to a very guarded prognosis in all cases of injury to the head that have been attended in the first instance with evidence of cerebral disturbance.

Surgery. Consecutive effects of injury to the brain.

*Hernia Cerebri.*—Hernia of the brain consists of a protrusion of a portion of the cerebral substance through the dura mater and bone, in the form of a tumor. It is remarkable that considerable masses of the brain may be destroyed or cut away, without injury to the function of the organ, or a fatal result. Hernial protrusion, therefore, is not dangerous so much by the abstraction of a part of the encephalic structure, as by the attendant evils by which the bulging of a portion of so soft an organ through a small aperture is caused and accompanied. When an aperture exists in the vault of the cranium, the brain is seen pulsating within the dura mater, and at every systole of the heart tending to rise up into the opening. When the dura mater is entire, this membrane forms a sufficient barrier against any partial expansion of the brain at the seat of an orifice in the bone; but even then, if this orifice be large, the dura mater yields somewhat, and is subjected to injurious pressure against the sharp, and often irregular, border of the bone. If the integuments be judiciously brought into contact with the fibrous covering of the brain by gentle compression, and if the reparative process advances favourably, the brain

Hernia cerebri.

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Surgery. Hernia cerebri.

is permanently retained within its proper limits, though it may be ever after felt through the skin, beating in unison with the heart's action. But if, from any cause, the dura mater be deficient, if it have been lacerated, or if it give way by ulceration, the brain is thrust out slowly beyond it by the gradual expansion it undergoes by the rush of blood within its vessels.

The manner in which this protrusion is effected occasions a greater change in the relative position of the cerebral matter at the part than at first sight appears. The convolutions immediately over the bulging mass are expanded, and there is, as it were, a rush of the medullary substance from all sides towards the point of eruption. By this the vessels are dragged and torn, and blood is poured into the tumor either at several small spots, or in greater quantity, so as to form a clot. When inflammation ensues in this situation, the protrusion is still further increased by the attendant engorgement of the vessels, and the same effect may be further heightened by purulent effusion. The tumor thus projected is sometimes as large as an orange.

There are instances of slight hernia cerebri having been cured, under favourable circumstances, by judicious pressure; but where the natural coverings are deficient to any great extent, the cases of it are entirely hopeless. It is impossible to return the protruded organ into its proper position; any attempt to press it back instantly occasions the symptoms of compression of the brain, and the preliminary step in the treatment must consist in shaving off the projection at the level of the dura mater. The integuments are then to be brought together over the aperture, and kept down upon it by an equable compress, for which a piece of cork or sheet lead serves as a good foundation. But in the vast majority of such cases, it will happen that this repression is sooner or later attended with bad consequences: the inflammatory process is too apt to lead to suppuration, either on the surface or in the interior of the cerebral substance, and the resulting effusions are pent up with the effects of compression. The artificial compress being removed, the protrusion recurs, the disorganizing process goes forward, and so the patient perishes.

The loss of a large mass of brain is sometimes sustained without any interruption to the function of the organ, or any ultimate impairment of its powers. So long as the rest of the viscus is uncompressed and healthy, it will, for the most part, suffice for its offices. The brain is a double organ, and one hemisphere may play the part usually performed by both. Thus injuries have been received attended with the loss of considerable portions of the convolutions, and the patients have recovered without either paralysis or intellectual defect; but, of course, the liability to inflammation and destructive changes in wounds of such great extent is too great to allow of such a result in any but very rare instances. The total insensibility of the superficial parts of the brain is strikingly shown in these cases, as well as where the surgeon has to cut away a cerebral hernia.

As the head is, philosophically speaking, an expansion and modification of certain vertebræ, and the spinal column contains parts strictly analogous to those of the cranium, it might be expected that a close relation would subsist between the injuries and diseases of these respective structures; and this is, in fact, true.

Surgery. Injuries of the spine.

The injuries of the Spine are chiefly important as they affect the delicate nervous organ enclosed with the bony column. Like the brain, the spinal marrow may suffer concussion, which will be marked by an instantaneous, but temporary, annihilation of its functions of sensation and motion, the intellect remaining clear. Again, it may undergo laceration and rupture of vessels, with their attendant symptoms of paralysis, convulsions, &c., without the existence of fracture; or, finally, the vertebræ, deeply seated, and interlocked and covered as they are with fleshy parts, may themselves sustain shocks too violent for them to withstand, and which occasion their fracture and displacement, with necessary damage to the spinal marrow.

From the depth at which these injuries are situated, their precise extent and nature are often exceedingly obscure, and can only be judged of by the symptoms referable to the marrow. Fortunately, these usually afford whatever knowledge is necessary to direct the surgeon in his measures of relief, which are much restricted by the very nature of the injury, and the parts affected by it. It is not admissible to make mechanical efforts to replace any fancied displacement, as more harm than good may result from them; and the proposal made many years since by that eminent surgeon, Mr. Cline, to trephine the vertebral laminæ, with the intention of elevating sunken fragments, after some few totally ineffectual attempts at carrying it into effect, has fallen into deserved disrepute.

Injuries of the spinal cord are distinguished from those of the brain by the occurrence of paralysis below the injured point, while the cerebral functions remain unimpaired. There will also be pain and tenderness at the seat of the hurt. The precise spot of the injury is further declared by the resulting obstruction to certain functions. Those disorganizing the cord in the lumbar or lower part of the dorsal region of the spine are attended by palsy and loss of sensation in the lower extremities, and lower part of the trunk—by paralysis of the sphincters of the anus and bladder, leading in the former case to involuntary discharge of the fæces, and in the latter to inability to void the urine. When the injury is higher in the dorsal region, the intercostal muscles are also paralyzed, and the ribs do not share in the movements of respiration. If the cervical region below the fourth vertebra be the seat of the injury, more or less of the upper extremity partakes of paralysis or anæsthesia, and the precise seat of the damage may sometimes be divined from the participation of particular nerves only in its effects. But where the injury is situate above the origin of the phrenic nerve—that is, above the third vertebra of the neck—it occasions immediate death, by putting a complete stop to respiration: the diaphragm is now paralyzed, as well as the intercostal muscles.

The result of these injuries will depend on their place and extent. They are, in general, less fatal the lower they are situated; but if the destruction of the cord and of the surrounding structures be great, recovery can scarcely be looked for. In the injury low down, the patient may slowly regain more or less of the use of his limbs, and of the power over his evacuations; but more commonly he lingers through several weeks or months in a state of helplessness, and ultimately falls a victim to the accident. The bladder has to be relieved from the first by the regular introduction of

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Surgery. Injuries to the spine.

the catheter at intervals of five six or hours. If this be neglected it becomes distended with the secretion, which then escapes by the mere physical resistance of the walls of the cavity, and the tone of the organ becomes impaired or utterly ruined; and, moreover, the urine putrefies in the bladder, and the ammonia thus generated acts as a powerful irritant to the mucous membrane, which becomes inflamed, pours out blood and mucus, and may be even entirely destroyed by sloughing. These changes in the urine are promoted by a change in its chemical characters when it is secreted in the kidneys, and which seems to be a consequence of the cutting off the nervous influence from those glands. Weak injections of nitric acid and of aqueous solution of opium into the bladder have been found very efficacious remedies under these circumstances.

Whatever may be the position of the injury, it will be advisable to draw blood from the arm, or, if possible, largely from over the part itself, if the state of the pulse should be such as to indicate the presence of inordinate vascular action; and after some time has elapsed, the same end may be further answered by blisters. The alvine secretions must be solicited by purgatives, and great care must be taken that no sloughs form upon the sacrum or hips, the best preservative against which will be protective plasters, and the use of Dr. Arnott's water bed. These measures comprise almost all the aid that art can offer in these deep-seated and severe hurts; whatever degree of ulterior improvement may be looked for, must be at the hands of time and nature.

Those in whom the spinal cord is disorganized, so as to leave respiration to be conducted by the diaphragm only, do not survive more than three weeks, and usually die much within that term. That muscle, though it is the principal agent of respiration, yet is not sufficient of itself to preserve the function in integrity, while the system is burthened by the local effects of a severe injury, and when the abdominal functions are likewise so much deranged. The immediate cause of death is, in most cases, a slow asphyxia.

### Fractures.

Fractures.

Fractures are important injuries on several accounts. The violence that produces them is usually great, and frequently implicates the soft parts to a serious extent: the process of reparation is slow, and if not skilfully seconded by the practitioner, will end in deformities or useless limbs. Many fractures prove fatal by the inflammation or gangrene that attends them, in consequence of the surrounding injury. The most important practical division of fractures is into the *simple* and *compound*, the latter being distinguished by the wound of the bone being continuous with a wound of the integuments. In this case the risk is far greater than in simple fracture, for reasons that will be apparent as we proceed.

Their varieties.

Fractures are also usefully distinguished as transverse, longitudinal, and comminuted, terms sufficiently explicit not to require definition. These varieties in the mechanism of the fracture depend in part on the direction in which the force has acted, partly on its degree, and the surgeon should mark them with a view to his treatment. In transverse fractures there is commonly but slight displacement, while in the oblique and comminuted forms the broken ends will overlap by the contraction of the muscles.

Causes.

Some causes predispose to fracture, such as old age, in which the bones are brittle, from a deficiency of the firm substratum of cartilage which endows the osseous tissue with its peculiar toughness and elasticity. Some diseases of the bones, such as mollities ossium, cancer, and rickets, have a similar influence. The two former of these are affections of the adult, and consist respectively in a morbid deposit of lardaceous and cancerous matter in the vascular interstices of the tissue, leading, by their pressure, to the gradual absorption of the natural structure. Under these conditions a very trivial blow, or the slightest muscular effort, will sometimes occasion a fracture; but when the bones are healthy, great violence or powerful muscular action is commonly required to produce this effect. Mechanical force may be applied in two ways; viz., either directly to the part which suffers, as when the cranium is beaten in by a hammer, or the thigh-bone crushed by a waggon wheel passing over it, in which case the soft parts commonly partake largely of its effects; or indirectly, as, for example, when the collar-bone breaks across in the centre, from a blow or fall on the shoulder.

Symptoms.

The ordinary symptoms of fracture are deformity, unnatural mobility, and crepitus, or grating of the fragments on motion. The deformity is the result of the displacement of one or both fragments, either by the force which produced the fracture, or by muscular action. The limb may be turned in a wrong direction or bent, and it is generally shortened by the overlapping or riding of the pieces. The mobility may be evident from the parts below obeying the influence of gravity, or only by the hands of the surgeon twisting the limb to endeavour to elicit crepitus. This last symptom, when clearly marked, is decisive of the presence of fracture; but when slight, it does not greatly differ from the rough grating sometimes felt when diseased ligamentous structures are rubbed against bone. With a fracture there is also usually considerable pain, more or less tumefaction, and inability on the part of the patient to move the part. When fractures are deep-seated, when they occur near joints, or when the fragments are not displaced, they are sometimes difficult to detect. In all cases the particulars of the accident should be inquired into, before an examination is instituted into the condition of the injured part; since the previous information thus acquired will give a clue to the nature of the injury, and thus save the patient from a prolonged examination.

Reparative process.

When a bone is fractured blood is of course poured out from the ruptured vessels of the bone, periosteum, and surrounding soft parts concerned in the injury; but unless a large vessel be wounded this hemorrhage is slight. The blood diffuses itself in the cellular tissue and forms a coagulum between the broken extremities of the bone. In the course of a few days lymph is given out from the small vessels and mingled with the blood, and is gradually converted in two or three weeks into a firm reddish semi-transparent substance, termed *callus*, from the erroneous notion that it served to cement the ends like an inorganic material. This callus is full of blood-vessels, and there soon appear in it minute points of bone, which extend throughout its mass, until the whole is ossified. This process is usually completed in from one to two months. The callus invests the extremities of the bone in the form of a case,

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Surgery.

Process of reparation in fractured bones.

thickest opposite the fracture, and reaching some way above and below. Within the medullary cavity (if it be a long bone) there also appears a cylindrical mass of callus, connecting the fragments. This callus is not a permanent structure; hitherto the opposed surfaces of the bone are not adherent; and this only exists while their slow union is being consolidated, through a period of from four to six months, according to various circumstances; it is then slowly absorbed. Two circumstances are necessary in the most healthy subject for the union of fractured bones:—1. A certain apposition of the fragments; 2. Rest. If a large piece of a bone be extracted, as of a rib, new bone does not grow to supply the deficiency; but if fragments overlap one another, even though they are at some little distance apart, they will often adhere through the abundance of the callus. If the constitution be debilitated, and the powers of nutrition much impaired, reparation by bone will not take place, even though the above conditions are diligently observed. Anxiety of mind and the continued influence of the depressing passions interfere in this way, as well as certain morbid states of the fluids of the body—as that causing the sea-scurvy. It is related, in the account of Lord Anson's voyage, that when a large portion of the crew was afflicted with this dreadful scourge, bones long since fractured, and which had been firmly united, loosened as completely as though they had been recently broken, and only became again knit as the constitutional taint was removed by its appropriate remedies. Cicatrized ulcers also broke out again in a corresponding manner. Bony union may also be prevented by a dead fragment of bone interposed between the broken extremities, and it may be retarded by inflammation and suppuration occurring in the textures which ought to be concerned in the deposit of the new material. It is not a little remarkable that in rickets, a disease of the nutrition of the bones, by which they are predisposed to fracture, consolidation should be perfectly effected within the ordinary time.

False joints.

When, from any of the former causes, union by bone is prevented, a *false joint* is formed. This usually consists of ligamentous matter stretching between the fragments, and allowing a certain degree of motion between them, their rough extremities being at the same time rounded off by partial absorption. It will happen, if the parts have been permitted to move on one another during the formation of this fibrous structure, that cavities of variable size will be found between its fibres, and, if large, they may perhaps be said to resemble the cavity of a natural joint, especially when they contain a viscid fluid analogous to synovia. It has been said that cartilage like the articular cartilage is sometimes generated on the exposed surfaces of the bone; and though this is not incredible, it must be very rare. The usual condition presented by bones exposed to friction on one another is that of extreme compactness and smoothness of surface, so that they have an appearance not unlike porcelain (porcelanous degeneration).

When, the natural term of union arriving, the surgeon finds the bone still loose, much may be done to promote union; for the above condition is not yet produced, and it may be possible to restore the ossifying disposition. It will be his duty to search diligently for the cause, and to remove it if it be within his reach. A nutritious diet,—a return to accustomed stimuli,—a better regulation of the secreting functions,—change of scene, may be the general measures required; and a moderate amount of continued pressure, and even of friction, may be applied to the seat of the fracture, with a view to excite the action of the vessels around it. The patient was recommended by Mr. Hunter to put the part for a short time to its natural use, as the leg to being stood upon, with the idea that this would excite in it actions appropriate to fit it for its function; but, apart from the theory, the practice was a good one, if cautiously pursued. In older cases of non-union, the object is to stimulate the parts to throw out callus; and this is to be effected only now and then, and with difficulty. A proposal of Mr. White, a surgeon of Manchester, to cut down upon the false joint and saw off a small piece from the extremities of the bone, and afterwards to replace the ends in apposition, and treat the whole as a compound fracture, has been tried on a few occasions with success; but on a far greater number it has failed: and for this reason, joined to its difficulties and severity, it has given place to a plan devised by Dr. Physick, a pupil of Hunter, which consisted in passing a seton through the fractured part, with a view of lighting up inflammation, and thus effecting the union of the bone. We extract the following account of the first case in which it was tried:—"Before passing the needle (18th Dec. 1802) I desired the assistants to make some extension of the arm, in order that the seton might be introduced as much as possible between the ends of the bone. Some lint and a pledget were applied to the orifices made by the seton-needle, and secured by a roller. The patient suffered very little pain from the operation. After a few days the inflammation (which was not greater than what is commonly excited by a similar operation through the flesh of any other part) was succeeded by a moderate suppuration. The arm was now again extended, and splints applied. The dressings were renewed daily for twelve weeks, during which time no amendment was perceived; but soon afterwards, the bending of the arm at the fracture was observed not to be so easy as it had been, and the patient complained of much more pain than usual whenever an attempt was made to bend it at that place. From this time the formation of the new bony union went on rapidly; and on the 4th of May, 1803, was so perfectly completed, that the patient could move his arm in all directions as well as before the accident happened. The seton was now removed, and the small sores occasioned by it healed up entirely in a few days. On the 28th of May, 1803, he was discharged from the hospital perfectly well; and he has since repeatedly told me his arm is as strong as ever it was." Since this case was published the operation has been successfully performed in many instances, and though it has sometimes failed, it must be regarded as a considerable improvement on the means of relief previously at our disposal.

Treatment of non-union of fractures.

Treatment of fractures.

In fractures which compel the patient to observe the recumbent posture for a considerable time, as in those of the thigh and leg, it is of importance that the bed should be so firm as not to yield much to his continued pressure, because the sinking of his body will be very apt to displace the upper fragment of bone. A board should be placed under all, and the feather-bed under the mattress. It will be also convenient if the central part of the mattress be made of a separate piece, so that it can be withdrawn for his evacuations without disturbance to his posture. A draw-sheet will

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Surgery. Fractures. Treatment.

also be useful, for a similar reason. The first thing to be done with the fractured limb itself is to bring it into as natural a position as possible. This is to be effected partly by a change of posture,—by relaxing those muscles the contraction of which has been the chief cause of the displacement. The surgeon cannot efficiently perform this essential part of his duty without a competent knowledge of the situation and actions of the muscles on the skeleton, and of the mechanism of the particular fracture he may be treating. If the limb be not laid in the posture which on the whole is least apt to disturb the bones when set, the after part of the cure is likely to be retarded by the ends rising out of their place, or by the unconscious efforts of the patient to alter the attitude given him by the surgeon. If the broken ends overlap, the limb is then to be lengthened or *extended*. The upper part is fixed by an assistant, while the surgeon grasps the lower with his hands, and pulls upon it until the fragments are in the same line. He will be materially assisted in this by having previously relaxed the muscles: this is what is meant by *setting*. The bone has now to be retained in position by suitable apparatus. These ordinarily consist of splints, compresses, bandages, and a variety of mechanical contrivances adapted to particular fractures, all of which may be included under one or other of the above-mentioned heads. The common splint is a strip of wood glued to stout leather, and then split up, so as readily to conform itself to the rounded surface of a limb. Splints are also made of other resisting materials, such as sheet-iron: a soft pad is always interposed between them and the skin, which may be covered in most instances with a bandage. Compresses are used to determine pressure to particular spots, to distribute it over the irregularities of a limb, and to retain the soft parts in a compact state around the bone. The splints are to be fixed by tapes, tied moderately tight. An important practical rule must be observed in the first application of a retentive apparatus to a fractured bone,—viz., to observe the state of tumefaction, which invariably follows a fracture when complicated with much injury to the soft parts. If this have not already taken place the bandages must not be drawn tight; they had better even not be applied at all until the swelling arises, since they are liable to constrict the limb when it swells, and to prevent the return of blood, causing vesications, and even gangrene.

Some surgeons, after the tumefaction has a little subsided, apply a starch or *dextrine* bandage, which, on hardening, forms a firm and unyielding case accurately fitted to the limb, and incapable of changing its shape. This is worn during the whole progress of the cure. Others employ it only in the latter stage of the reparative process, finding it inconvenient to be unable to inspect the state of the limb from time to time. This practice, if employed from the first, has the disadvantage of encasing the limb in a composition that may be moulded to any bad position that the bones may take ere it be dry; and that cannot be removed without considerable delay and difficulty in case of any untoward circumstance arising that may require a change of the dressings. In this country it has been allowed to fall very generally into disuse, although but recently introduced; it is, however, a convenient splint to enable the patient to rise from bed and take moderate exercise after the third week, and for this purpose safer and less cumbrous than all others. During the cure of a fractured bone, and especially during the first fortnight, the constant attention of the surgeon is demanded to subdue inflammation and to prevent displacement, and this can be best accomplished where the apparatus is easy of removal.

Compound fractures.

The nature of the injury in *compound fractures* renders necessary some important differences in the treatment. The bone may ride up through a hole in the integuments made by its sharp extremity, and it may be requisite to saw off a portion, or to enlarge the wound, in order to restore it to its place. It may be broken into numerous fragments by direct violence, as by a musket-ball; and some of these may be loose in the wound or driven among the muscles. All such should be extracted, if possible, at the earliest moment, since, if allowed to remain, they can only act as foreign bodies and excite inflammation, leading to suppuration and sinuses, and preventing union. There may be extensive destruction of the skin and other soft textures; or the main artery of the limb may be torn through; or a joint may be implicated in the wound, sometimes by the fracture running into it. All of these circumstances form complications of the gravest kind; and any two of them occurring together, particularly in the lower extremity, are usually sufficient to make amputation necessary. The surgeon has to consider—first, whether the risk of life will be materially diminished by this severe alternative; and, secondly, if life be secure, whether the limb can recover so as to be of use to the patient: he looks not only to the immediate, but to the ultimate, result of the case; and has often to determine and act decisively under circumstances of peculiar doubt and responsibility. If the main artery be wounded he knows the difficulty of securing it, and remembers, that though in a sound limb the circulation might be diverted into collateral channels, yet that here the general tumefaction and inflammation of the tissues will seriously interfere with this salutary process; and that if immediate sphacelus is escaped, yet the tedious and wearing course of a large suppurating surface, and the reparative process itself, stand but a poor chance of being adequately supported by a vascular system locally debilitated. If the skin be bruised or lacerated, so that a great portion of its circuit round the limb must perish, recovery would still offer too poor a substitute for the healthy member to make it worth the danger incurred in the attempt to save it. If a joint be entered, the constitutional disturbance will be far greater; and if the patient survive, the articulation will be useless. But death follows, sooner or later, in so many cases of compound fracture into the larger joints of the lower limbs, that it is a general rule in surgery to amputate in such cases. At all times the surgeon's decision on this all-important question must have a regard to the age, constitution, and mode of life of the sufferer,—the young and healthy having far greater resources against such a strait than the old in years or constitution. The remedial means at hand have also to be considered; as an amputation may reduce a wound, certain to be protracted and complicated in its course, into one requiring only simple measures for its speedy cure. Thus, in military operations in the field, amputations are necessary in many cases which might have recovered without them in the more secure and tranquil asylum of a civil hospital.

Question of amputation.

The local treatment of compound fractures comprises

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Surgery. Treatment of compound fractures.

the reduction of the bone to its place, and the retaining it there, as well as the dressing of the wound of the soft parts. There is more swelling than in simple fracture, therefore the retentive apparatus should be less firmly applied and the limb attentively watched, in case the bandages should require to be loosened. Where the wound is small, an endeavour should be made to unite it by the first intention, which, if it succeeds, reduces the injury to a simple fracture, and greatly promotes the rapidity of the cure. If the wound be a contused one, and adhesion is hopeless, simple dressing should be used, and the suppurative stage encouraged by every means in our power. Great care is requisite to prevent the pus formed from burying itself in the recesses of the wound and lodging there, as this untoward circumstance enlarges the sphere of the morbid action and leads to death of the exposed surfaces of the bone, as well as to other evils, which it is the duty of the surgeon to foresee and counteract. Sometimes incisions must be made to give vent to matter burrowing in situations remote from the outward orifice already existing; but these may in general be avoided by judicious pressure, by compresses, and skilful bandaging. Bleeding from the arm is required in young and robust subjects, when the inflammation runs high; but the lancet must be employed with the caution which the certainty of the approaching drafts on the powers of the system ought to inspire. The antiphlogistic treatment is to be pursued until suppuration is established; opium, given in moderation, is useful to quiet irritation and procure sleep.

Reparative process in compound fractures.

The reparative process, after a compound fracture with suppuration, differs slightly from that we have above described, as occurring in simple fracture: it is rather allied to the granulating than the adhesive process, in wounds of the soft textures. Callus is thrown out in the neighbourhood of the suppurating surface of the wound, and gradually increases so as to fill up the interval between the bones, and obliterate the cavity of the wound. While this is slowly proceeding, the callus first formed is undergoing ossification. If portions of the fractured extremities perish, they are thrown off by a tedious process of absorption of the surface of the living parts next to them; and the wound does not finally close up until these *sequestra* are discharged, which is often many months in being effected.

Particular fractures.

We shall now offer a few observations on some of the principal fractures which call for the aid of the surgeon, rather with the view of illustrating our previous general remarks, than of giving a complete account of the subject, to do which would carry us far beyond our limits.

Fractures of the ribs.

The fractures of the bones, forming the great cavities of the body, may be classed together as being chiefly important, from the participation of the vital organs they enclose in the consequences of the injury. Fractures of the head and spine have been considered elsewhere, and we may now advert to those of the *Ribs*. These bones being much exposed to violence, and of a slender structure, are very liable to fracture, which usually occurs near their greatest convexity, and in several contiguous ones at the same time. The attachment of the ribs to the vertebræ and sternum by ligaments, and to one another by the intercostal muscles, does not allow their broken ends to become displaced, except inwards or outwards; and thus often renders a simple fracture difficult of detection, especially if it exists only in a single bone. Crepitus may be felt when the patient breathes or coughs, if the hand be laid on the bone near the fracture; or if this symptom be wanting, he will feel pain when the rib is pressed at a distance from the part hurt. In ordinary cases, all that is necessary is to restrain the movements of the ribs by a moderately tight girth of flannel, which, by its elasticity, accommodates itself well to them, and leaves respiration to be performed chiefly by the diaphragm. This bandage is worn for a fortnight or three weeks, after which the provisional callus is sufficient to prevent movement of the fragments on one another.

When the fracture is caused by direct violence, the ribs may be beaten in upon the lung and wound it, thus forming a severe complication. The symptoms of this will be expectoration of blood in small quantity, with constantly recurring cough, attended with great pain. The distress and anxiety of countenance will be greater, and there will probably be an escape of air from the lung into the serous cavity of the thorax, and thence into the cellular membrane of the body through the seat of fracture. This inflation will be recognized by a diffused puffy painless swelling, crackling under the fingers as the air is pressed from one place to another. This emphysema of the thoracic walls is of no consequence in itself, but only as an indication of the injury to the lung. In slight cases the wound in this viscus is almost instantly closed, so that but little air enters the pleura; but when it remains open sufficiently long the lung collapses, and the serous cavity is filled with air. Thus one-half of the respiratory apparatus is rendered useless, and the motions of the diaphragm are greatly impeded by the accumulation of air. The wound being open, the air is driven by the expiratory movements of the walls of the chest into the cellular tissue outside the ribs, and thence it may permeate the whole of the body, if the pumping action of the thorax continues long enough. A patient, under these circumstances, is in imminent peril of death from suffocation: he pants for breath like an asthmatic, his inspirations being rendered irregular and snatching by the pain. His countenance is livid, and he cannot lie down; he is agonized by incessant cough. The treatment, under these circumstances, has usually consisted in puncturing the wall of the chest, with a view of letting out the accumulated air, and allowing the diaphragm to move equably—a proceeding that has sometimes been attended by relief, but has more often proved ineffectual; for unless the air could be forcibly extracted the lung would not expand, nor the diaphragm be relieved. Punctures may be made in the external parts to diminish tension, and allow them to receive more air from within the pleura; but general bleeding is the most important remedy. This not only diminishes the chance of inflammation in the wound, but, what for the moment is even more important, it reduces the volume of the circulating fluid in proportion to the reduced size of the respiratory organ. In all cases of fractured ribs, where the lung appears overloaded, this is the most valuable measure of relief to which we can have recourse. The air is subsequently absorbed into the blood-vessels, and the wounded lung expands: opiates are to be cautiously given to diminish the distressing cough.

In compound fracture of the ribs, the air enters the pleura from without, and the lung collapses. If it be



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Surgery. Compound fracture of the ribs.

wounded, this collapse often becomes a salutary circumstance, preventing hæmorrhage by closing up the wound; but bleeding, in such cases, is apt to occur from the intercostal artery, which takes a course under the rib. It may bleed inwardly, which will be known by the faintness induced. If possible, the artery is to be secured by a ligature, which may be passed round it by a curved needle. If the external wound be small, it may be possible to introduce a tube, and suck out some of the air from the pleura, which will cause the lung to dilate; after which, strapping is to be applied to draw the lips of the orifice together. But more commonly, in these accidents, several ribs are broken together, or it is a gun-shot wound, and such a proceeding would be impracticable. If a detached fragment of bone, or a ball, have been driven in, it may lodge in the lung, or may gravitate to the lowest part of the pleural sac: it will then usually be hopeless to endeavour to extract it, and more mischief than good would result from such efforts. A bullet may be surrounded with lymph, and be permanently fixed, if the patient is kept in one posture sufficiently long to allow of the consolidation of the new material. Penetrating wounds of the thorax, without fracture, are attended with many similar symptoms, and require very similar treatment.

Fractures of the sternum.

Fractures of the *Sternum*, or breast-bone, are rare: they are always occasioned by direct violence, and are commonly attended with a depression at the injured part. The general symptoms, and the treatment, do not differ in any important respect from those of fractured ribs.

Of the Pelvis

The strong arch of the *Pelvic* bones is never broken without extreme violence, which generally inflicts serious injury on the important viscera within: the colon, or bladder, or urethra, may be ruptured, or the great vessels torn. These accidents are often caused by a fall of earth in embankments. The rupture of one of the hollow viscera is attended with an extravasation of their contents into the peritoneum, which almost invariably proves fatal in a few hours; or the patient may survive a few days, and die from the inflammatory results of the injury. When the fracture runs across the arch of the pubes, the urethra may be lacerated across—an accident that will be known by bleeding from the canal, and by great pain, and perhaps swelling, in the perinæum. The patient cannot evacuate his urine; it extravasates into the cellular membrane of that region, and around the bladder in the track of the fracture. When this occurs abscesses form, and ossific union is prevented: there is retention of urine and distension of the bladder, which, if not relieved, becomes inflamed and sloughs, and the patient perishes. In this case it is the surgeon's first duty to endeavour, with great care, to pass a catheter past the rupture into the bladder. If he succeed in this before extravasation has occurred, the urine will probably flow past the fracture without insinuating itself between the fragments; but if there be reason to apprehend a dispersion of this irritating fluid beyond the canal, a free incision should be made into the membranous portion of the urethra (which is always the part torn), by cutting on the catheter. This effectually prevents further extravasation among the tissues, by affording it a free and direct exit. The treatment of the fractured bones themselves is confined within very narrow limits, —rest in the horizontal posture, and a simple bandage encircling the pelvis to preserve immobility. The bowels are to be kept moderately free. The consequences, on a recovery, will very probably be some deformity and awkwardness in gait, depending on the particular nature of the fracture and the attendant displacement. Fractures of the projecting parts of the pelvis, such as the wing of the ilium, are less severe in their results, being produced by a less amount of force, and often unaccompanied by serious disorder of the contained organs. The detached fragment may be moved, and crepitus felt: it should be retained in place by bandages, as accurately as circumstances will permit.

Surgery. Fractures.

Fractures of the thigh.

Fractures of the *Thigh-bone* present great varieties, according to their situation and other circumstances. In fracture of the shaft, which usually happens by force directly applied, or by a fall from a height on the feet, the upper fragment is drawn forwards by the action of the muscles fixed to the lesser trochanter, while the lower is dragged upwards behind it by the hamstrings, so as to shorten the limb by two or more inches. The direction of the fracture is often oblique, and favours this displacement: when the patient lies down, the foot falls outwards. In healthy persons this fracture, if simple, does well, uniting in the usual time; but the muscles tending to produce overlapping of the ends of the bone are very powerful, and some degree of shortening is not an unfrequent consequence, in spite of care and skill on the part of the practitioner. Pott inculcated a flexed posture of the thigh and leg, with splints from the hip to the knee, the patient reclining on the injured side: and, doubtless, many limbs thus treated have been preserved straight, and of their proper length. But continual care is required to effect this, and in many instances a repeated re-adjustment of the splints is made necessary, by the movements of the body affecting the upper fragment: the patient unconsciously leans over on his back, while the limb is bound down on its side. Thus the union is apt to take place with the foot turned outwards in an ungainly manner, offering an impediment in walking. A double inclined plane, with splints for the thigh, is a better apparatus: its inconvenience lies in the tendency of the trunk to slip off it, and carry the upper fragment inwards. But, perhaps, the best splint for this fracture is that contrived by Desault, and now known by his name. It is placed on the outer side of the limb, and extends from the arm-pit to below the heel: it is first fixed by a band passed between the thigh and scrotum, and fastened to the splint above, and which may then be carried round the trunk. The limb is then extended, and the foot bound down to the lower end: the limb is then bandaged to the intermediate part of the splint. By this apparatus the thigh is kept extended, and the upper fragment, with the trunk, kept in a line with the lower. The inclined plane, however, is to be preferred in compound fractures, as being more calculated to allow of frequent change of dressings.

Fractures of the upper extremity of the femur are of two kinds, those occurring within the capsule, and those occurring on its exterior. The former happen to persons, especially women, advanced in years, from slight falls on the foot, sometimes from falls on the hip itself. This part of the bone is not only atrophied in aged persons, but also rendered more horizontal in its direction, and thus is less able to resist forces applied to it through the shaft. The latter are also more fre-

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Surgery. Fractures of the thigh-bone.

quently met with in old persons, though they may happen to those of almost any age: they are always occasioned by falls on the hip, or other direct violence. In fracture *within the capsule*, the limb is usually shortened by from half an inch to two inches, and the limb is everted; though sometimes, when the fragments are interlocked, neither of these symptoms is present, and the limb may in rare instances be even inverted. Crepitus is not felt until the limb is drawn down to its natural length and rotated, for without this precaution the fractured surfaces are not in contact. In this fracture it is impossible that the provisional callus should form, and, moreover, the detached head of the bone is nourished only by a slender anastomosing vessel, running to it in the round ligament that attaches it to the acetabulum, and is thus incapable of undergoing osseous union, except in very rare cases. The neck of the bone becomes in great part removed by absorption, and the surfaces adapt themselves to one another: the remnant of the neck plays in a socket, formed partly by a condensation and scooping of the cancellated structure of the head. The upper part of the capsule, now receiving the pressure which the acetabulum did before, becomes greatly thickened and almost cartilaginous. A very useful limb results, though necessarily attended with deformity. The conditions now related show the wisdom of Sir A. Cooper's advice, not to bind up this fracture, and confine the patient for months, in the hope of bony union occurring: such a course wears out her remaining strength. She should be allowed to assume an easy posture in bed, and begin to move about with crutches in the third week. In fracture outside the capsule, either at the base of the neck or through the trochanters, there is not so much shortening and eversion, and crepitus is felt much more easily. There is more pain and swelling, callus is thrown out in abundance, and ossific union occurs. In this fracture, therefore, the means already described for keeping the fragments in contact are to be employed. It sometimes happens that the limb is inverted instead of being everted, which is caused by the peculiar obliquity of the line of fracture, the chief rotators outwards remaining with the upper fragment, and the insertion of the anterior fibres of the two smaller glutei (which turn the thigh inwards) with the lower. There is generally deformity after this accident, on account of the impossibility of adapting any retentive apparatus on the parts: it frequently proves fatal in old persons.

Fracture of the lower extremity of the femur into the knee-joint is an accident of great severity. The blood extravasates into the joint, the inflammation is great, and requires the most active antiphlogistic treatment to prevent disorganization, or at least anchylosis of the joint. It is difficult under these circumstances to apply splints, and the subsequent deformity is sometimes considerable. The outer condyle is apt to be united in a higher position than natural, thus giving an obliquity to the articular surface, which throws an undue strain upon the internal lateral ligament, and leaves the joint weak ever afterwards. Passive motion must be used towards the fourth week, to prevent false anchylosis.

Of the Patella

Fractures of the *Patella* are of two kinds: the most common is that caused by the powerful action of the extensor muscles. The patient slipping backwards makes a sudden effort to save himself, and snaps the bone across. The fracture is transverse, and the upper fragment is drawn two or three inches from the lower, which is retained in its place by the ligamentum patellæ passing to the tubercle of the tibia. Blood is, of course, effused into the joint, which throws out an increased quantity of synovial fluid. There is a wide gap between the fragments, into which the fingers sink. There is, of course, total inability to extend the leg, and great pain. The limb is to be laid in an extended posture, with the heel raised on an inclined plane to relax the rectus muscle of the thigh, the only extensor coming from the pelvis. Care must be taken not to bandage the knee too tightly before tumefaction arises: leeches may be applied if the inflammation seem to require it. When this has diminished, or at first if it be only slight, a compress may be placed above the upper fragment, and this made to descend towards the lower by proper turns of a roller, or an apparatus devised by Mr. Lonsdale may be used. This consists of a steel ring padded, and with a cushion which is to be fixed above the upper fragment by a screw: a circular bandage is then passed round the knee, and to this the ring and cushion are drawn by straps, thus preventing all constriction upon the limb. In about a month passive motion must be commenced, to prevent adhesion to the condyles of the femur. The union is always by ligamentous substance, which usually suffers some elongation by use, but without impairment of the movements of the limb. The other variety happens from a direct blow on the bone, as by falling on the knee from a height, or on the edge of a stair: this is the *starred* fracture. The bone is split up into many pieces, the fragments are but little separated, the parts are much bruised, there is great ecchymosis, pain, and tumefaction. The subsequent inflammation runs higher, and demands more vigorous treatment. The retentive apparatus cannot be applied so soon; but when the swelling is in course of subsidence, the fragments may be brought more effectually together, and bony union be expected. After fractures of the patella, a knee-cap should be worn for some months, as a protection to the joint and a security against a recurrence of the accident. Compound fracture of the patella is a case usually calling for amputation.

Fractures of the leg.

Fractures of the bones of the *Leg* are very common from falls and direct violence. When the tibia is broken, the fibula generally gives way too, but often at either a higher or lower point. The fibula, however, frequently snaps two or three inches above the ankle, by sudden twists of that joint, without the tibia suffering, except at the summit of its malleolus, by a drag on the internal lateral ligament. In fractures of the leg there is danger of the shin protruding through the integuments, especially if it present a sharp splintered extremity. The lower fragment is drawn up behind it by the flexor muscles. The limb may be bent and laid on the side, resting upon a splint with a foot-piece. It is then to be extended by the foot, the knee being fixed by an assistant; and when the bones are reduced to their positions, the foot is to be bound down to the foot-piece. Another splint is now to be laid along the limb, and should extend below the ankle, and the whole tied with tapes and confined on an ample pillow. The tendency of the toes to drop outwards should be counteracted by suitable pads, and the patient made to keep his hip well under him. Sometimes a narrow splint may be advantageously applied



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Surgery. Fractures of the leg.

along the shin, but with caution lest the skin be made to slough by being pressed against the bone; or the patient may be placed on his back, with the limb elevated on a double inclined plane, the splints being applied on the sides, and the foot supported by a foot-board, which may be adapted to draw downwards, and so extend the limb. The heel often sloughs in this apparatus, unless a nest be hollowed out for its reception. The inclined plane, or some one of its numerous modifications, is particularly adapted to compound fractures of the leg, as the side splints admit of such ready removal and replacement in the daily dressings; and the front being uncovered, lotions or poultices may be employed without inconvenience. These fractures require no special remarks. In the fracture of the fibula above the outer malleolus, with laceration of the internal malleolus or ligament, commonly called Pott's Fracture, a restoration of the fragments to their proper place is often difficult. The lower fragment is sunk in towards the tibia by the outward dislocation of the foot, to which it remains attached by the external ligaments. The foot is rotated upon its long axis, the outer edge being directed upwards. On returning it to its natural position, and drawing it forcibly inwards, the outer malleolus is acted on by the fulcrum of the lower end of the tibia, and thereby lifted out of its hollow. This was clearly pointed out by Dupuytren, who used a peculiar splint for retaining it in place. This consists of a straight splint, to be laid on the tibial side of the leg, and to project beyond the foot: its pad is to be gradually thicker as it approaches the ankle, and there to cease altogether; so that there remains a wide interval between the splint and the foot. The splint being fixed by bandages as far down as the ankle, the foot is to be drawn and fixed inwards to the splint, beyond the line of the leg. This ingenious contrivance is to be retained for three weeks, when, the provisional callus being formed, it may be removed, and a plain roller substituted: any inversion of the foot may be easily remedied, by applying the splint for a day, on the outside of the limb. The importance of lifting out the sunken end of the fibula is seen in cases where it has not been effected. The interval between the malleoli is wide, and the joint loose. The reparation also about the inner malleolus has not proceeded favourably, and that region of the joint continues weak, and unable to sustain the increased stress that is laid upon it.

Fractures of the foot.

Fractures of the *foot* being usually the consequence of direct force applied to the part, are apt to be attended with such severe injury to the soft parts as to render amputation necessary. In such cases the surgeon should remember that the more he can save the better, consistently with his duty of making a serviceable stump. The line of separation may be that between the metatarsal and tarsal bones, or that in front of the os calcis and astragalus, as circumstances may determine; or the bones may be sawn across in the interval. If amputation be not deemed necessary, a splint on the sole is requisite. If inflammation run high, it is to be combated by leeches, &c., and matter is to be evacuated early, by incisions through the plantar aponeurosis.

Fractures of the clavicle.

The *clavicle* is broken very frequently, being a slender bone, and the structure that ordinarily receives the principal force of blows inflicted on the shoulder. If a person is pitched upon this part the clavicle suffers. It may be dislocated; but it is usually fractured about its middle. It is also exposed, by its superficial situation, to the effects of immediate violence. The injury is easy of detection: the outer fragment is pulled downwards by the weight of the arm, and the inner remains stationary between the sterno-mastoid and great pectoral muscles. It is easy to restore the position of the fragments, but difficult to retain them during the time necessary for the union; hence frequent deformity. The apparatus devised by Desault is very useful. When this is not at hand, a pad should be fixed in the axilla by a handkerchief passing round the neck; the shoulder should then be drawn upwards and backwards, and fixed by a figure-of-8 bandage crossed between the scapulæ; the elbow is afterwards to be brought over the chest, and supported high in a sling. Three handkerchiefs may be made to answer the same purpose. The bandages will have to be replaced after a time. No pad is to be applied to the fractured part.

Of the acromion process.

The *acromion* process of the scapula may be struck off by a fall on the tip of the shoulder; the deltoid muscle instantly draws it down, thereby removing the prominence of the shoulder. On elevating the arm the fragment is brought to its proper level; and on rubbing it against the opposite surface, crepitus is felt. This accident is to be distinguished from dislocation of the humerus. The cure requires attention on the part of the surgeon. If the piece unite at an angle, it encroaches on the arch under which the head of the humerus moves, and restricts the movements of the arm; or it may unite by ligament only. The patient should keep his bed, and the arm be separated from the side to relax the deltoid; if he must be up, a graduated pad must be interposed between the arm and side so as to effect the same object, and the elbow must be raised in a sling.

Of the body of the scapula.

Fracture of the body of the *scapula* may occur in almost any direction, and is the result of immediate violence. The displacement will vary with the line of injury, and will be little under the surgeon's control. He will endeavour, by varying the position of the arm, to bring the parts into as close apposition as he can; and will then pass broad bandages to bind the scapula to the thorax. If there be comminution of the bone, the displacement is likely to be considerable and to interfere permanently with the free motions of the part. Fractures of the coracoid process are rare, and are to be recognized by pressure on the part. The neck of the scapula is occasionally broken; the glenoid cavity then drops with the arm, and the shoulder has a sunken flattened appearance below the acromion. It may be taken for dislocation of the humerus into the axilla, or for fracture of the neck of that bone. From the former it is easily distinguished; and if the accident be recent, a careful examination will commonly enable the practitioner to discriminate it from the other. When a portion of the border of the glenoid cavity is chipped off the nature of the injury remains obscure.

Of the humerus.

The *humerus* may be fractured in the shaft or at either extremity: the fracture of the shaft is known at once by the unnatural mobility, the deformity, and crepitus. This is amongst the simplest of all fractures in its nature and treatment. Splints are placed on three or four sides of the arm, from the shoulder to the elbow, after the fragments are brought into a line: the elbow is allowed to hang, and the wrist supported in a sling. Fracture of the upper extremity may occur either above

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Surgery. Fractures of the humerus.

or below the tuberosities which receive the insertion of the scapular muscles. In the former case, which is rare, the displacement is slight, but the arm drops a little inwards; in the latter case, the shaft of the bone is drawn inwards by the powerful action of the great pectoral muscle and of the latissimus dorsi. Crepitus is felt when the bone is pushed outwards and raised. The arm is to be separated from the side by a thick pad; splints are to be applied, and the arm supported by a sling.

The lower end of the humerus may be broken in several directions, which it is important to distinguish. There may be an oblique fracture above the articular eminences; the deformity will be somewhat like the dislocation of the fore arm backwards, the radius and ulna, with the lower fragment, being drawn up behind the other by the triceps extensor cubiti. There is great tumidity in front by the projection of the brachialis muscle on the upper fragment. The fragments are generally replaced without difficulty; but to retain them in position is not easy, on account of the swelling that commonly accompanies the injury and the small purchase that can be obtained upon the lower fragment. The limb is to be laid upon a pillow in as good a posture as possible, and covered with a light roller and fomentation. When the inflammatory swelling has in some measure subsided, a pasteboard case may be adjusted to the elbow, from the middle of the arm to the middle of the fore arm: this, when soaked in warm water, is moulded to the shape of the parts, and, when dry, serves to retain them during the remainder of the cure. The fracture may descend between the condyles into the joint, either with or without the transverse fracture: in this case the inflammatory action and swelling are greater. The nature of the injury may be known by observing the motions of the joint to be free, and by the existence of crepitus above. The condyles are movable on one another. The same treatment is to be pursued. Passive motion must be used during the third week, to prevent adhesions in the joint; but however carefully this direction is attended to, the perfect integrity of the articulation is but rarely preserved. Either of the condyles may be broken off by a direct blow; and the inner, as being the more prominent, the more commonly suffers. This accident is often attended with great pain from the pressure on the ulnar nerve, which descends immediately behind that bony eminence. There is rarely any serious displacement in these injuries, and a suitable compress and roller are all the applications necessary.

Fractures of the olecranon.

The *olecranon* is fractured by a person falling on the elbow, as when it is thrust out for support when the hand is engaged. A hollow is felt, the fragment being dragged upwards by the triceps. It may be moved from side to side, but can with difficulty be brought down into its place, even when the fore arm is extended; there may, therefore, be no crepitus. This injury is seldom repaired by bone; and in this and other respects much resembles the fracture of the patella. The fragment is to be brought, if possible, into close contact with the bone, by bracing it down by a compress, after partially extending the elbow. A pad is to be placed in the hollow of the joint in front, with a splint in front of it, to preserve it motionless. Passive motion must be commenced in the third week.

Of the fore arm.

The *fore arm* is much exposed to fracture, from its exposed situation. The injury, whether in one or both bones, is readily detected by grasping the fragments and moving them in opposite directions: if the radius be broken below the tubercle the upper fragment is advanced by the biceps muscle, and the lower drawn inwards towards the ulna by the pronators. The object in this and the other fractures near the middle of the fore arm is to prevent undue approximation of the radius and ulna, and to keep the two fragments of the radius in the same degree of supination; for if the lower be pronated and the upper supinated, and they grow together thus, it is manifest how limited these movements must be in future, and if the bones adhere to one another these motions of course cease. The elbow is to be bent, to relax the biceps; the hand is to be placed supine on a splint reaching to the ends of the fingers; another splint is to be adapted on the front of the fore arm as far as the palm. The limb is then to be brought across the chest, and supported in a sling, the hand being allowed to drop towards its ulnar border. This last precaution is especially requisite in fractures of the radius alone, since the weight of the hand is thus made to act as a constant force counteracting the pronator quadratus, through the external lateral ligament. Fracture of the lower extremity of the radius is a very common accident, and apt to be overlooked from the difficulty of detecting crepitus. The wrist is bent backwards: there is an unnatural prominence in front, just above the joint, with extreme pain. A displacement of the head of the ulna frequently accompanies this fracture. This injury is remarkably prone to be followed by a painful, weak, and almost useless state of the wrist, with deformity. To prevent this, two splints, firmly applied, are to be made use of. It is impossible to counteract completely the powerful and direct action of the pronator quadratus dragging the lower fragment forwards and towards the ulna.

Of the wrist and hand.

The bones of the *wrist* are not liable to simple fracture. The *metacarpal bones* frequently give way under blows received on their distal extremities. The best treatment consists in a ball compress held in the fist, the fingers being bandaged over it: this prevents bulging of the fragments towards the palm.

Of the nose.

The *nasal bones*, when fractured by a blow, are to be restored by a director covered with lint introduced into the nostril. There being no muscular displacing cause no retentive apparatus is necessary, and the case is to be treated as an ordinary contusion. There being commonly great tumefaction, fomentations should be applied. Emphysema occasionally attends this accident.

Of the lower jaw.

Fractures of the lower jaw usually occur between the angle and symphysis, in front of the masseter. The lesser fragment is drawn upwards by the muscles of mastication, and the irregularity is recognized in the row of teeth. When the line of fracture is at the symphysis there is scarcely any displacement, owing to the equal action of the muscles on the two sides. Sometimes the jaw is broken on the two sides at once. Crepitus is always perceptible. The best apparatus is one invented by Mr. Lonsdale, consisting of two curved pieces, one below the jaw, the other fitting on the lower range of teeth, and both fastened by means of a screw. This allows the jaw to open, while it retains the fragments immovable on one another. If it be not at hand, two contiguous teeth may be secured to each other by dentists' silk, and a pasteboard splint applied wet and allowed to dry; the split double-headed roller may be

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Surgery.

used in addition, a slit being made in the centre of it to admit the chin. Two of the ends are to be tied over the vertex, and two over the occiput. The ramus or neck of the jaw may be fractured; but the injury, even if detected, is too deeply seated, and the upper fragment is too small, to admit of surgical apparatus being employed to set it. All that can be done will be to preserve the jaw motionless.

Dislocations.

### Dislocation.

A dislocation is a displacement of an articular surface of a bone from its natural situation. Dislocations are commonly produced by violence, but they may occur as an effect of mere muscular action, or of relaxation of the ligaments, or deficiency of the structures of the joint, or from disease attended with their destruction. Dislocations from violence may be regarded as contused and lacerated wounds, for the displaced bone being driven from its place into the surrounding muscles or other structures, is attended with more or less injury to them, and with effusion of blood. There is, moreover, the presence of the dislocated bone pressing upon them, and acting to some degree as a foreign body in the new cavity it has formed for itself. The ligaments being designed to limit movement of the joints in certain determinate directions, it is almost invariably only by a rupture of some of these structures, and of course of the synovial capsule, that the dislocation can occur at all. The pain attending dislocations is usually of a dull but severe kind, and arises more from the continued pressure of the bone on the soft parts, and especially on nervous trunks that may happen to be near, than from the extent of their laceration; hence it is almost immediately relieved by the return of the bone to its natural position. The external signs by which a dislocation may usually be known and distinguished from a fracture are the sudden occurrence, after an accident, of some unnatural swelling in the neighbourhood of the joint, with a corresponding alteration of form on the opposite part; great limitation of motion determined by the impaction of the bone in its new site, or by the muscles stretched unduly over its projecting parts; an absence of the grating sound and feel termed *crepitus*, which is distinctive of fracture.

Signs

It often happens that these signs are obscured by immense swelling of the part, caused, it may be, by effusion of blood, or by effusion of synovia from the torn membrane, or by inflammatory deposits in addition to these. Under such circumstances there is no alternative but to wait until the tumefaction has in some measure subsided, and until it allows the forms of the projections of the joint to be recognized. It is often impossible for the best informed surgeon to determine with accuracy the nature of such injuries; but it is fortunate that he can frequently apply suitable remedies without this precise information. If with this great swelling there is great immobility, not from voluntary muscular efforts to prevent pain, but from mechanical causes, he may suspect dislocation, and must wait for a time before he can hope to reduce it; applying leeches, or fomentations, as he would for a mere bruise. But if he finds preternatural mobility, and, above all, crepitus, he knows that fracture exists, and that, though there may be also dislocation, he must be content to treat the injury as though there were not. These observations apply only to extreme cases; the general rule never to be lost sight of is to restore the displaced parts as early and as completely as possible to their natural situation.

Surgery.

Compound dislocations.

Dislocations in which the displaced bone is forced through the skin are termed compound; they in some measure resemble penetrating wounds of joints, the textures of the articulation being exposed to violent inflammation when laid open with the external surface. The injury done to the soft parts will be often so extensive as to make amputation necessary. The propriety of resorting to this extreme measure will be determined on grounds similar to those existing in cases of severe compound fracture. If an attempt is to be made to save the limb, the bone is to be reduced, if necessary, by sawing the protruding portion, or by dilating the orifice in the skin; the limb is then to be placed in a fixed position, and simple dressings applied.

The consequences of an unreduced dislocation are permanent deformity and more or less impairment of the motions of the joint. The displaced bone gradually acquires a socket among the neighbouring textures, a part of which is usually constituted of the bone near the original joint, and the rest is formed of new bone deposited around, and of ligamentous substance. These new tissues are the result of the pressure which the bone exerts, and the surface which is formed is made smooth and adapted to the configuration of the dislocated bone by the movements of the latter upon it. Thus the movements, which were at first of the most restricted kind, become by degrees more free, and much of the use of the member is restored. Sir Astley Cooper, in his great work on this subject, has admirably displayed the changes consequent on unreduced dislocations.

The joints are the centres of motion of all the bones, and when a bone is removed from its fulcrum it makes another of the new parts on which its extremity rests. The muscular spasm, produced by the pain, presses the bone against these parts, and thus tends to drive it further and further from its former resting place. In almost all dislocations the muscles have been the main agents in drawing the bone from its original position, when from some cause it had been disengaged from the opposite articulating surface. These organs, therefore, usually form the chief obstacle to reduction, and their direction and attachments around every joint should be well studied, in order that the surgeon may be enabled to comprehend clearly how he may best overcome their efforts. He should also know, by the external signs, in what course the displaced bone has run, and what mechanical obstacle to its return may exist. To enter into a consideration of these circumstances would lead us into greater detail than the size of the present article would admit of, and we shall merely notice some general means for removing the resistance of muscular spasm. In the faintness generally consequent on the injury, the muscles are inactive and relaxed, and this favourable moment should if possible be seized for restoring the bone. But it seldom happens that the nature of the accident is recognized so soon; and then faintness may be artificially induced, in obstinate cases, by blood-letting, the warm bath, and tartar emetic, of which perhaps the two last are to be preferred, except in plethoric and muscular individuals, when all of these means may be put in practice simultaneously. The surgeon's mechanical efforts consist, first, in extending or stretching the dislocated limb, so as to bring the displaced surface to its

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Surgery.

Disloca-tions.

natural level, and next, in so moving it, either by direct force applied to it, or by making a lever of the bone, as to replace it on the surface naturally receiving it. Various contrivances have been devised for making extension effectual; the pulleys are universally preferred where sustained and equable force is demanded, but in many cases the simple power of the surgeon's arm will be sufficient. Bandages or towels, fixed to the limb, serve to protect it at the part to which the drag is applied.

Dislocations being sometimes overlooked through carelessness or ignorance, or not being reduced in consequence of the swelling attending them (perhaps the patient was at sea or otherwise out of reach of medical aid), it becomes a question how long after the reception of the injury an attempt at reduction may be justifiable. Sir A. Cooper is averse to make this attempt in the dislocation of the shoulder after three months, and in those of the hip after two; but some cases have been related in which, after a longer interval than these, considerable advantage has accrued from efforts at reduction. It is to be considered that here there will already have been formed a new cavity for the reception of the dislocated bone, while the old one will be more or less filled up, and the surrounding textures will have accommodated themselves to the unnatural posture of the parts. If the bone is made thus to regain its proper situation it often will slip back on the least encouragement, and has to be retained immovable for a time, that nature may undo her previous work of accommodation. But if its complete restoration cannot be effected at one sitting, it may at several, in which gradual efforts are made to disunite its new-formed adhesions, and replace it in its original site. Even though these fail, increased mobility may result sufficient to compensate the patient for the pain he submits to. The surgeon has to guard against rough handling, which will bruise the nerves, tear the vessels, and cause sloughs. A limb thus treated has been paralyzed for life.

We shall now briefly advert to the dislocations occurring at the principal joints,* among which the first in importance are those of the *hip*, the most perfect example of the ball-and-socket joint, and surrounded by strong and powerful muscles, but liable to dislocation from the extent of its natural motions, and the variety of directions in which forces are capable of acting upon it. For the practical surgeon the study of these accidents possesses great interest, because his success in reduction will depend entirely on a correct diagnosis of the injury. The most common is that in which the head of the bone is thrown upon the dorsum of the ilium, the trochanter major resting near the anterior spine of that bone, and the direction of the neck being upwards and backwards; "the motion of the joint is diminished, the limb is rotated inwards, and its length diminished by nearly two inches; the natural projection of the trochanter is lost, and there is diminution of roundness in the injured hip." "This dislocation may be caused by a fall when the knee and the foot of the patient are turned inwards, or by a blow, whilst the limb is in that position; but it most commonly occurs

Of the hip.

in consequence of the person falling whilst carrying a heavy weight on his shoulders, or from a heavy weight, such as a mass of earth, falling on the back whilst the body is bent forwards in a stooping posture. We shall give the mode of reducing this dislocation in Sir A. Cooper's own words, from which the reader will obtain also a correct idea of the general plan to be adopted in other severe cases. "Let the patient," says he, "lose from twelve to twenty ounces of blood, or even more if he be a very strong man; then place him in a warm bath, at the heat of 100°, and gradually increase it to 110°, and give him half a grain of tartarized antimony every ten minutes, until he feels some nausea. The patient should now be wrapped up in a blanket and be placed on his back upon a table of convenient height, between two staples; a strong padded girth should be passed round the hip, with an opening in it sufficiently large to admit the injured extremity, and to press upon the perinæum on one side, and the crista of the ilium at its other point of bearing, the extremities of this girth being firmly fixed to one of the staples, so that they form a line continuous posteriorly with the direction of the dislocated thigh. This part of the apparatus is for the purpose of firmly fixing the pelvis, and forms what is termed the counter-extending force. A wetted linen roller is next to be tightly applied just above the knee, and upon this a leathern strap is to be buckled, having two short straps with rings at right angles with the circular part, or, instead of this, a round towel, made into the knot called the close hitch. The knee is to be slightly bent, but not quite at a right angle, and to be brought across the thigh a little above the knee, which position not only places the extremity in the best direction for the extension, but also prevents the apparatus from slipping. The pulleys are now to be fixed to the two rings of the circular girth (or to the towel) and to the opposite staple, thus completing the arrangement of the extending force. The surgeon should now draw upon the cord of the pulleys so as to tighten the whole apparatus, the patient having been so placed that the direction of the extending and counter-extending forces together form a straight line in the direction of the long axis of the dislocated limb. The extension should be continued by drawing upon the pulleys so as to tighten, even to stretching, every part of the apparatus; and should the patient now complain of the severity of the pain, the surgeon should wait a little, to give the muscles time to become fatigued; he then renews the extension, and when the patient suffers much, again rests, until by degrees the muscles yield and the bone approaches the acetabulum. When it reaches the lip of that cavity he gives the pulleys to an assistant, and desires him to preserve the same state of extension, while the surgeon rotates the limb gently inwards, but not with a violence to excite opposition in the muscles, during which act the bone usually slips into its place. When the pulleys are employed, the head of the femur does not usually return with a snap into its socket, in consequence of the continued extension to which the muscles have been submitted having overcome their contractile power: the surgeon has no other means, therefore, of ascertaining whether or not the reduction has been effected than by loosening the bandages and comparing the length of the two limbs, unless he be able to ascertain it from measuring the distance of the trochanter major from the anterior and superior spinous process of the ilium and sacro-coccygeal articulation.

Surgery.

Disloca-tions of the hip.

* See Sir A. Cooper's work on *Dislocations and Fractures of the Joints*, new edition, by Bransby Cooper, F.R.S., London, 1842; to which we have to express our obligations in preparing the following sketch.

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Surgery. Dislocation of the hip.

If it be ascertained that these distances are the same on both sides, it may be inferred that the dislocation is reduced. Such precaution should always be taken before the apparatus is removed; for nothing can exceed the distress which is invariably expressed if the patient be obliged to submit to its second adjustment.

"It often happens that the bandages get loose before the extension is completed, an accident which should be carefully prevented by having them well secured at first; but if they require to be renewed, it should be expeditiously performed to prevent the muscles having time to recover their tone.

"A considerable difficulty sometimes occurs in raising the bone over the edge of the acetabulum; to overcome which a towel should be passed under the thigh, as near the joint as possible, to enable an assistant to lift it. When the reduction is completed the injured limb should be kept parallel with the sound one, by the aid of a bandage; for, in consequence of the relaxed state of the muscles, there is great liability to the recurrence of its displacement unless such precaution be adopted. It is also necessary, as after-treatment, when such force has been employed, to administer both constitutional and local means to subdue the subsequent inflammation. The patient, under all circumstances, should be kept in bed for at least a fortnight after the accident, to allow of the reparation of the inward structure of the joint; and even then, should he be allowed to use the limb, passive motion should be employed."

The dislocation into the *Ischiatic notch* is a variety of that last described, the head only resting nearly on the level of the acetabulum, instead of considerably above it. There is very little shortening, but the same inversion of the foot, and immobility. The head of the bone is deeper and consequently less easily felt; and hence the nature of the injury is more obscure. It is occasioned by force acting on the thigh when bent at right angles to the pelvis, and inclined over the other limb. It may be reduced by laying the patient on the sound side, bringing the thigh over the middle of the opposite limb, and making extension in that direction. As the brim of the acetabulum is deeper behind than elsewhere, the head of the bone must be raised by a towel placed under the thigh near the perineum. The reduction of this dislocation is not easy.

The dislocation into the horizontal ramus of the *pubes* is marked by distinct signs. The limb is shortened by about an inch, and the foot turned outwards. It is abducted, the knee being directed away from its fellow. The trochanter is sunk, the head of the bone prominent below Poupart's ligament. It happens when a person, while walking, puts his foot into some unexpected hollow in the ground, and his body at the moment being bent backwards, the head of the bone is thrown forwards upon the os pubis. A gentleman who had met with this dislocation in his own person informed me that it happened whilst he was walking across a paved yard in the dark; he did not know that one of the stones had been taken up, and his foot suddenly sunk into the hollow, and he fell backwards. When his limb was examined the head of the thigh bone was found upon the os pubis.* The patient is to be laid on the unaffected side, and the limb extended by means of the pulleys in a downward and backward direction. The head of the bone may then be brought over the brim of the acetabulum by a napkin passed under the thigh.

Dislocation into the *thyroid foramen* is distinguished by very well marked signs. The limb is lengthened by nearly two inches, and the psoas and iliacus muscles being stretched by the head of the bone thrust under them, the thigh is partially flexed on the pelvis; or if the patient stands, he leans forwards, with the foot in advance and the knees widely separated. The trochanter is sunk, and the head of the bone can be felt in its new situation, unless the patient is corpulent. The limb cannot be brought over the opposite one. This dislocation is "generally caused by a heavy weight falling upon the pelvis, whilst the back is bent forwards and the thighs are separated from one another. The ligamentum teres and the lower part of the capsular ligament are torn through, and the head of the bone becomes placed in the posterior and inner part of the thigh, upon the obturator externus muscle." Extension is not necessary. The object is to throw the head of the bone outwards and forwards, after which the muscles will restore it to its socket. This is effected by laying the sufferer on his back with a firm fulcrum (as a bed-post) between the thighs, and the pelvis fixed. The limb is then to be firmly drawn over towards the opposite one, when the desired motion will be communicated to the head. The direction of this may be guided by direct pulling at a towel passed round the upper part of the thigh. Care is to be taken not to advance the limb, lest it should slip round below the acetabulum into the sciatic notch, instead of reentering the socket.

Of the knee.

Dislocations of the *knee* are rare, which is to be explained by the great strength of its crucial and lateral ligaments. The *tibia* is sometimes thrown backwards towards the ham, but seldom or never completely detached from the condyles, without such injury to the soft parts as renders amputation necessary. The reduction is easily effected, and the limb must be kept bound up and at rest for a few weeks, until all inflammatory symptoms have subsided, and the laceration of the ligaments be repaired. The *knee-cap* may be thrown from its pulley on either side, but may be readily replaced by relaxing the extensor muscles and pushing it into its place. In some rare cases it has been found turned round, so that its posterior surface was anterior, a displacement very difficult to remedy.

Of the ankle.

The *foot* is usually dislocated *outwards* at the ankle with fracture of the fibula, as already described. There is no obstacle to reduction. The *foot* may be displaced *inwards* with fracture of the tibial malleolus. Both these injuries are to be treated as fractures after the parts are reduced. The latter is the more serious accident of the two, more force is requisite to produce it, and it is usually accompanied with more contusion and swelling of the soft parts and more injury to the bones and ligaments. In dislocation of the foot *backwards* the instep appears shortened, the heel lengthened. "The lower extremity of the tibia forms a hard projection upon the upper part of the middle of the tarsus under the projected tendons, and there is a depression before the tendo Achillis. This accident arises from a fall of the body backwards whilst the foot is confined; or if a person jumps from a carriage in rapid motion, with the toe pointed forwards." The fibula is fractured a little above the ankle. The parts are replaced with little difficulty by the aid of moderate extension.

* Sir A. Cooper. *Op. Cit.*, p. 84.

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Surgery. Dislocation of the ankle.

*Compound* dislocatioo of the ankle, in which the tibia projects over the instep, stretching the extensor tendons over it, is in general an injury demanding amputation. This is especially the case if the patient be old or in bad health, or if the injury have been caused partly by direct violence. On the other hand, if the patient be young, and there be little contusion of the surrounding structures, an attempt may be made to save the limb. If this be determiaed upon, it may be necessary to saw off a portion of the protruding bone, or to enlarge the wound, in order to effect reduction. The subsequent treatment does not require particular ootice io this place.

Of the foot.

Of the bones of the tarsus the only one subject to separate dislocation is the *astragalus*, which is occasionally shot out of its place and lodged under the skin. The bone is fouod turned from its natural direction, and sometimes completely reversed, so that its lower surface looks upwards. It is seldom possible to restore this bone; never, if the displacement is complete. It has been cut out in a few instances, and with an excellent result as regards the usefulness of the foot. The skin, if not lacerated at first, rarely escapes sloughing from the pressure occasioned by the irregular projections of the upraised bone.

Of the jaw.

The *jaw* can only be dislocated *forwards*, an accident commonly happening on both sides at once, from yawning, or during a burst of immoderate laughter. The condyles rest on the transverse root of the zygoma, the mouth remains widely open, and the dislocated bone projects. There are depressions in front of the ears, in the natural position of the joint, and the cheeks are bulged. The compressed parotid yields saliva in abundance. It sometimes happens that one of the condyles only is dislocated, and this will be readily recognized. The jaw is twisted from that side. In either case the reduction is easy. The thumbs, armed with a towel, are to be placed on the lower molar teeth, and the jaw depressed; the front of it is now to be elevated by the fingers, when the condyles are lowered and slip back into their sockets with a snap. Some persons appear liable to this accident from an original weakoess in the maxillary articulation, and those who have once suffered from it are very subject to its recurrence.

Of the clavicle.

The *clavicle* may be dislocated by the same kind of force which usually produces fracture of the bone. It may give way at either extremity. Its sternal eod may ride inwards over the front of the sternum, or its acromial end upwards upon the process of that name. Both of these displacements declare themselves by evident signs, and both are very apt to return after reduction. The treatment is the same as that required for fracture of the clavicle, and its object is to elevate and keep outwards the shoulder. Moderate pressure, however, must here be made on the clavicle to counteract its tendency to slip again from its position. The bandages must be worn longer in these than in most other dislocations, and whatever care be taken some deformity will remain.

Of the shoulder.

The *humerus* may be dislocated at the shoulder in several directions, but of these by far the most important is that into the *axilla*. The causes of this dislocation, according to Sir A. Cooper, are falls upoo the hand or elbow when the arm is raised from the side; but the most frequent cause is a fall directly upon the shoulder on some uneven surface, by which the head of the bone is driven downwards, whilst the muscles are unprepared to resist the shock. The head of the bone rests against the scapula and subscapular muscle, immediately below the glenoid cavity. The capsular ligament being ruptured in that direction, the great vessels and nerves are often compressed by it. The limb stands out from the side and cannot be brought to it without great pain. The shoulder loses its rotundity, seems flattened, and a depression may be felt below the acromion. The deltoid passes towards its humeral insertion at an unusual angle, and the head of the bone is readily distinguished in the axilla, if the arm be raised. There are many modes of reducing the humerus from the axilla. The pulleys may be employed: the arm is raised to a right angle with the chest. Extension is made from the lower end of the humerus and counter extension by a band passed round the thorax and scapula. When it has been continued sufficiently long the surgeon is to place his arm under that of the patient close to the axilla and lift the humerus towards the gleooid cavity, at the same time depressing the elbow towards the side. Another method less formidable in appearance, and which rarely fails, is as follows:—The patient lies on a sofa, while the surgeon, taking off his shoe, places his heel in the axilla, and then makes gradual extension by the wrist, or by means of a towel passed round the limb above the elbow. In a short time he brings the arm over the chest, making a fulcrum of his heel, when the bone re-enters the socket with a snap. The brachial plexus of nerves is apt to suffer in this operation, though, if it be done dexterously, but little force is required. Or the arm may be forcibly elevated towards the head, in doing which the acromion is converted into a fulcrum and the articular extremity lifted out from the hollow into which it had sunk.

Surgery. Dislocations of the shoulder.

The three other dislocations of the head of the humerus are *forwards* under the clavicle, *partially forwards* under the coracoid process, and *backwards* below the spine of the scapula. In the former of these the symptoms are even more evident than in that into the axilla, the acromion being more pointed and the hollow below it more considerable: the head of the bone is on the inner side of the coracoid process. In *partial dislocation* the head of the bone is drawn forwards against the coracoid process; there is a depression opposite the back of the shoulder-joint, and the posterior half of the glenoid cavity is perceptible. The elevation of the limb is prevented by the head of the humerus striking against the coracoid process. In these dislocations the same measures (with slight variation io the direction of the extending force) may be pursued with success. The dislocation *backwards* is a rare accident, but cannot be mistaken, as there is "a protuberance formed by the bone upon the scapula, which immediately strikes the eye, and when the bone is rotated the protuberance rolls also. The motions of the arm are impaired, but not to the same extent as in either of the other states of luxation; and the direction of the limb is obviously behind the glenoid cavity." This dislocation is easily reduced either by throwing the arm upwards and behind the head, or by extension over the chest, or directly downwards.

Of the elbow.

Dislocation of the *radius and ulna backwards* is not uncommoa in young persons, in whom the coronoid process of the ulna is still small. The boy falling forwards on his hand, the ulna slips backwards over the trochlea of the humerus, and carries the radius with it.



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Surgery. Dislocations of the elbow.

The coronoid process rests in the olecranar fossa, and the olecranon itself, with the head of the radius, projects behind in a very characteristic manner: the fore arm is shortened, and there is an unnatural prominence in front of the joint. By a variety in the direction of the force, these bones may be dislocated *outwards* or *inwards, as well as backwards;* in which cases the signs are similar, with the exception of the lateral displacement, which is respectively present in each. Thus, in the first, the head of the radius is felt behind, and to the outside of the external condyle; and in the second, the external condyle seems unnaturally prominent. The *ulna* alone may be dislocated *backwards*, the radius maintaining its situation on the articular surface of the humerus. The fore arm is fixed at a right angle with the arm, and much pronated by the drag on the pronator muscles, caused by the separation of the two bones. All these varieties now mentioned have the common character of great prominence of the olecranon behind. They may all be reduced by similar means, the readiest and most effectual of which consists in the surgeon placing his bent knee in the hollow of the joint, and gradually flexing the articulation still more. Each bone is converted into a lever, for which the knee serves as a fulcrum, and thus the bones are disengaged from one another. The coronoid process is lifted out of its bed, and over the trochlea, and returns to its true position on the force being intermitted. The *radius* may be dislocated *forwards*. This accident is not rare in children, but is often overlooked from the facility with which it is reduced. In adults it is rare, but is also easy of reduction. The fore arm is pronated and semiflexed; the head of the radius is felt as a prominence in front of the humerus, above its natural place, and may be seen to strike against the humerus on bending the elbow. By making extension by the hand, the bone is brought down. A dislocation of the *radius backwards* is described, but is very rare. The head of the bone projects behind the outer condyle, and may be at once reduced by forcibly bending the elbow.

Of the wrist.

Dislocations of the *wrist* are uncommon, the displacements attending fractures of the lower end of the radius being often mistaken for them. The carpal bones may, however, in rare cases, be dislocated either forwards or backwards on the radius and ulna. These accidents will be easily understood by the form of the projecting bones, if they are seen at an early period after the injury; but when tumefaction or chronic thickening has taken place, they may be confounded with fracture of the radius. The reduction is easy, but the usual means for counteracting inflammation must be afterwards vigorously pursued, and the hand and arm confined on a splint. A weak joint is commonly the result. The radius is sometimes separately thrown upon the fore part of the carpus, and lodged upon the scaphoid bone and the os trapezium. The outer side of the hand is, in this case, twisted backwards, and the inner forwards: the extremity of the radius can be felt and seen. This, and the separate dislocations of the ulna, which are rare, do not require further mention in this place.

Of the hand.

The dislocations of the thumb and fingers are generally difficult of reduction, in consequence of the smallness of the part from which extension has to be made, the great strength of the lateral ligaments, and of the muscles which resist extension. The nature of the injury is at once evident. Extension is to be made by the knot called the clove-hitch, which becomes tighter the more it is pulled upon. It sometimes happens that even long-continued extension by pulleys fails in reducing the dislocations of the thumb. Under such circumstances, it has been recommended to divide the lateral ligaments of the joint, and this has sometimes succeeded, but it is apt to be followed by severe inflammation and destruction of the joint; and it is therefore perhaps the better plan to leave the dislocation unreduced, as a very useful state of the member may even then be obtained.

Diseases of the bones.

*Diseases of the Bones.*—Under this head we shall give a brief description of the principal varieties of disease affecting the osseous tissue. Bones being highly vascular organs, are liable to most of those diseases which affect the rest of the body; such as unnatural growth, or hypertrophy; deficient growth, or atrophy; inflammation, acute and chronic, with its results,—enlargement, ulceration or *caries*, suppuration, mortification or *necrosis*;—and morbid deposits or growths. The bones present great variations of size within the limits of health; their non-articular eminences are well-marked, in proportion to the muscularity of the subject. In the female, for instance, they are less distinct than in the male; in the powerfully muscular man, they are at the maximum of development. As Sir Charles Bell has remarked, a person of feeble texture and indolent habits has the bone smooth, thin, and light; while with the powerful muscular frame is combined a dense and perfect texture of bone, where every spine and tubercle are well developed. And thus the inert and mechanical provisions of the bone always bear relation to the muscular power of the limb; and exercise is as necessary to the perfect constitution of a bone, as it is to the perfection of a muscle. It is an interesting fact, that if a limb be disused from paralysis, the bones waste as well as the muscles.

Exostosis.

*Exostosis* is a term now restricted to tumors of true osseous tissue, growing from the surfaces of bones: they are slow in their progress, and not inclined to involve other structures, or to prove hurtful except by their size or position. They generally commence without assignable cause, and are more prone to appear on the femur, tibia, bodies of the vertebræ, cranial bones, and last phalanx of the great toe, than in other bones: they may occur either with a broad or narrow base. This disease is recognized by the hardness and fixity of the swelling, and by its history. If it be deemed necessary to remove it, this may be usually accomplished without difficulty by means of the cutting pliers if it be pedunculated, or by the saw if its attachment be broad. Care is to be afterwards taken to suppress inflammation, which is apt to extend along the bone into neighbouring joints. The disease is not liable to return.

Atrophy.

There are two forms of atrophy of bone, independently of those in which the osseous tissue is absorbed through the pressure of some encroaching disease: these are commonly known as *rickets* and *fragility* of the bones. The former, so common among the children of scrofulous parents, and in the ill-nourished ones of the lower orders, consists in a deficient deposit of earthy matter, the animal matter being probably of an unhealthy quality. In this disease the bones are so flexible, that they bend gradually under the weight that they may be called on to support, or under the ordinary continued action of the muscles. The lower extremities exhibit deformity first, and to the greatest degree;

Rickets.

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Surgery. Rickets.

and the direction in which they become bent is evidently influenced by the superimposed weight: the bend almost always appears as an aggravation of the natural curves of the bones. The rickety femur has always its convexity directed forwards; the tibia is convex forwards and outwards, and the fibula follows the same direction. When the nutritive powers of the system are fully restored, the deposition of earth goes on in its healthy proportion, the animal matter becomes healthy, and the bones acquire their due degree of strength and hardness. In the tibia of a rickety child Dr. Davy found, in one hundred parts, seventy four animal matter and twenty-six earthy, instead of about an equal quantity of both. Rickets, as already hinted, is only one part of a constitutional disease. It is usually preceded by paleness and flabbiness of complexion, impaired appetite, disordered assimilation, with unhealthy evacuations, and enlarged liver. The first indication of treatment is to correct the constitutional state: this is to be done by attention to air, exercise, and diet, by attention to the excretions, and by the exhibition of tonics. It has been attempted to favour the deposition of more earthy material in the bones by the exhibition of muriate of lime and phosphate of soda, in minute doses, long repeated; but experience has not served to confirm the hopes of benefit from these remedies that a consideration of the pathology of the disease appeared to hold out. With regard to exercise, it is obvious that it cannot be taken in the ordinary way, on account of the increased deformity that would necessarily result. The child is, therefore, to be encouraged to play about on the floor, or on the bed. If the affection be slight, and be limited to the legs, further distortion may be in some degree prevented, by the judicious use of steel spring supports, which have been employed for this purpose from an early period.

Fragility of the bones.

The *brittleness* of the bones in old age is due to an opposite cause, namely, the defective deposit of animal matter, so as to give an undue preponderance to the earthy material. But this state can scarcely be regarded as morbid: it is the natural result of the feeble condition of the powers of nutrition, which ensues in the advance of years, and it will vary in different individuals according to the original strength of constitution of each, and according to the freedom from exposure to debilitating influences. This *fragilitas ossium* is strikingly exemplified in the fracture of the neck of the thigh-bone, or through the trochanters, on a very slight fall. "When," says Sir C. Bell, "an old feeble lady, who has long kept her bed, trips on the carpet and falls on her haunch, the top of the thigh-bone is shattered like a piece of China."

Mollities ossium.

There are several forms of disease which lead to the destruction of the texture of the bones, by the deposit of some new and morbid material from the blood circulating in their pores. Among these we do not include the results of inflammation.

*Mollities ossium* is a term denoting a peculiar degeneration, by which the bones become soft and wax-like, and bend during life into very distorted shapes. The cancelli and minute canals of the bony tissue are loaded with a lardaceous substance, which augments at the expense of the natural structure, until a mere papyraceous shell remains, retaining the original configuration of the part, but which is so soft that it may be readily cut with a knife. This is a rare affection, of slow progress, and attended with pains in all the tainted bones. The subjects of it are usually adults, in which respect, as well as in the nature of the deposit, it differs from rickets. The constitutional symptoms that accompany it are such as denote a grave disorder of the nutritive function. Fœtid sweats and abundant urinary sediments are among the most remarkable of these; but little satisfactory is known as to the nature or treatment of this formidable disease, and it appears to advance in spite of remedies. The distortions of the pelvic bones in females, by which the cavity is rendered too narrow to allow of the extrusion of the fœtus, and the Cæsarian section is made necessary, are among the most serious evils attendant on this affection. The sacrum is thrust down by the weight of the body communicated through the vertebral column, and the sockets of the thigh-bones being kept up by the resistance of the lower extremities, the pelvic cavity is sometimes almost completely obliterated between these parts.

Malignant formations in bone. Cancer.

The foregoing disease has been frequently confounded with *malignant formations* in bone. Of these there are several varieties, all of which are usually coincident with the same diseased growth in other organs. The first is very apt to be present in middle-aged or elderly persons, chiefly females, who have been affected with the ordinary cancer of the breast. It is an interstitial deposit within the medullary cavity and cancelli of the bone, formed from the vessels of the medullary membrane, not expanding the bone, but causing its gradual absorption, so that such a bone when macerated exhibits numerous holes and deficiencies, as though worm-eaten. Such bones are of course rendered very brittle, and give way often on mere muscular exertion, at such places as have suffered the most from the aggressions of the morbid growth. These bones may be fractured as the patient turns himself in bed. The accident is accompanied with very little injury to the surrounding textures, and scarcely any blood is effused. No attempts at reparation are made, and indeed such occurrences, as they mark an advanced stage of the general malady, are commonly the forerunners of a speedy dissolution.

Medullary or hæmatoid sarcoma.

Another form in which cancer attacks the bones is that of the medullary or hæmatoid tumor, developed in the interior of their cancelli. This may occasion a swelling perceptible externally, and by its softness and elasticity giving a very deceptive feel of fluctuation to the fingers. If seated near a large artery, it may also acquire from it a very perceptible pulsation, which will have something of the diffused and expansive throb of an aneurism. This form of disease may occur in any bone: it often affects many at the same time; but the cranial bones, the humerus, and femur are those most liable to it. It generally appears at an earlier age than ordinary cancer, and may consist either of a uniform size-like mass of new material, or of a more vascular multilocular tumor, containing in its cavities blood, serum, or cerebriform structure. This last is the *fungus hæmatodes* of Hey, and is a malignant disease of very active powers of growth. If allowed to remain, it encroaches on the surrounding parts, and, approaching the skin, may burst through it, and expand as a bleeding and rapidly protruding fungus. Amputation performed at this stage has often proved ineffectual, the same disease recurring in the textures of the stump. And indeed the alternative afforded by the operation, where it is practicable, even at a much earlier stage, is so poor a



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Surgery. Tumors in bone.

one, that it may be doubted whether it will not accelerate death more often than it will eradicate the disease from the system. There are, however, cases of undoubted authenticity on record, where the disease has not re-appeared elsewhere, after early amputation, at least during a period of several years.

In a third variety, the morbid growth forms a tumor between the periosteum and the surface of the bone, the latter itself remaining nearly in its natural state. The new texture may be of various degrees of consistence and colour. It sometimes is soft and vascular, and of a dark sanious appearance, not unlike coagulated blood, and into this there may shoot a forest of spiculæ and laminæ of osseous tissue from the surface of the bone. When macerated, the new bone wears the very beautiful appearance often exhibited in museums under the name of *spicular* or *lamellar exostosis*: but the osseous transformation seems an unessential feature of the disease. This variety occurs more often in the head than elsewhere. At other times the growth is of moderate consistence, and similar in general aspect to a mass of brain; but more frequently it is of considerable firmness, and in parts approximates to the cartilaginous condition, and contains gritty particles.

Acute inflammation of bone.

*Inflammation of bone* occurs in several forms. Acute inflammation of the whole shaft of the femur or the tibia sometimes follows a slight blow, or exposure to cold, in children, especially those of the poorer classes, who are ill fed and poorly clothed. At the onset there is great and deep-seated pain of the limb, aggravated by pressure, with shiverings and all the other signs of severe symptomatic fever. The motions of the part can no longer be performed, and the patient refuses to bear his weight on the leg. The whole limb, in the interval of the joints, swells, and in the course of a week or more fluctuation becomes apparent, pus having formed between the periosteum and the bone, and burst out under the muscles. If the case be neglected, the matter extends in various directions among the soft textures, and makes its way to the skin in different places. If the cavity of the abscess be now explored with a probe, the shaft of the bone is found bare, and bathed in pus, and this sometimes so extensively, that the entire shaft is uncovered and dead. The most active measures are demanded from the very first commencement of the attack, to arrest the morbid action. Leeches, fomentations, with brisk aperients, are to be employed, and the part frequently examined, with a view to detect the first evidence of fluctuation, after which a free opening is to be made. If the symptoms are unremitted during a week, even though fluctuation be not perceptible, it is best to make an explorative puncture, because matter may form at that great depth without giving the ordinary evidence to the fingers, and an early evacuation is most important to prevent its burrowing and extending to other parts.

It seldom happens that an affection, so severe as we have now described, terminates before the limb is rendered utterly useless, by the destruction of nearly the whole bone, and amputation becomes the only resource.

Inflammation of the periosteum and surface of bone is usually partial, and connected with some constitutional taint, such as syphilis, or the mercurial cachexy. It occurs chiefly in exposed situations, as on the shin, border of the ulna, or the cranial arch, and the swelling occasioned by it is termed a *node*. Nodes vary much in their activity. Matter may form between the periosteum and bone, and may even open on the skin. The surface of the bone is then found bare, spongy, and inclined to exfoliate. Or matter once formed may be re-absorbed by the aid of blisters repeatedly applied over the part. Even though suppuration do not occur, the bone will swell and become spongy, new bone being deposited, and the periosteum thickened by an infiltration of lymph, this forming the chronic node. The general treatment is to be conducted on principles laid down in the article MEDICINE. The local applications are leeches, fomentations in the early stage, blisters, iodine, or mercurial plasters in the chronic stages.

Surgery. Diseases of bone.

Chronic inflammation of bone.

*Chronic Inflammation* may attack an entire bone, and even several bones, as a consequence of some constitutional complaint, the bones most liable to it being those of the leg. Its access is gradual, with pain of a dull, heavy kind, and deep-seated tenderness. The affected bones enlarge, the limb acquires a large misshapen appearance, the muscles falling away from inaction. This state of the bone is sometimes brought on by some slight accidental injury, acting in union with some predisposing cause, and in such instances the inflammation may run so high at the seat of the injury as to terminate in the death of more or less of the bone. This is what is technically called *necrosis*; the dead portion is detached by a slow absorption of the living bone in contact with it, and becomes loose, under the name of *sequestrum*. This lies in a cavity, surrounded by a mass either of newly deposited bone, or of old bone modified by inflammation, and from the surface of the cavity pus is secreted, which makes its way outwards through apertures in its sides, termed *cloacæ*.

Treatment.

The treatment of chronic inflammation of bone consists of all those measures which tend to improve the general heath, with rest, leeches, fomentations, and counter-irritants to the bone. Alterative mercurial medicines are generally of service, with iodine, quinine, or sarsaparilla, according to circumstances. When a portion of bone dies, the local swelling, the pain, the discharge of matter continue, and a probe introduced into the aperture commonly enables the surgeon to detect the presence of the sequestrum. If this be large, there will probably be several cloacæ, but it is often quite impossible to determine with accuracy the size of the dead portion. Under these circumstances a sufficient length of time having elapsed to allow of the complete separation of the sequestrum from the yet living parts, incisions are to be made down to the diseased bone, large enough to permit the extraction of the fragment. As it commonly happens that it is too large to be withdrawn through the cloacæ, the new bone that encloses it is to be cut through either with trephine, chisel, or saw. The sequestrum having been disengaged, the wound is to be dressed with lint and a poultice, the external part being left open to give escape to loose particles with the discharge, and then healing by granulation. The operation now described is sometimes a very severe one, and it is always attended with considerable suffering from the tenderness of the inflamed bone; but the relief that follows it is so immediate and permanent that there can be no doubt of its advisability at an early period, in the great majority of cases where a sequestrum has been ascertained to exist. There is no other cure; the sequestrum cannot, as was formerly supposed, be absorbed or dissolved by the pus that bathes its surface, and the patient is doomed to unceasing torture and anxiety, as well as to

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Surgery. Diseases of bone.

the inconveniences of an useless limb, as long as the sequestrum remains. Amputation has often been desired and performed for an old necrosis, but surely the operation just described is in most instances to be much preferred.

When the surface of a bone is destroyed, either by being stripped of its periosteum, or by the progress of an ulcer, or by any other cause, the dead part will separate as a lamina from the sound part below. This is termed *exfoliation*. It differs from the process last-mentioned in the absence of any new bone thrown out over that which has lost vitality, so that there is rarely any delay in the removal of the dead portion.

Abscess in bone.

An occasional consequence of deep-seated inflammation in bone is *abscess*. It would appear that a degree of this morbid process, which would terminate in necrosis in the compact texture of a bone, may lead to the formation of abscess in the cancellated or more vascular and extensible part. The abscess is chronic, rounded, circumscribed, and lined by a cyst. The surrounding bone becomes dense and thickened, but there may be little swelling apparent externally. These abscesses occur in the diploë of the flat bones, and in the spongy extremities of the long bones. The tibia seems peculiarly prone to be the seat of them. They are characterized by deep-seated, severe, aching pain, confined to a limited space, and incessant through many months or years. The only effectual treatment will be to cut down upon the bone, and to trephine over the spot indicated by the pain, as recommended by Sir B. Brodie. If matter be found, relief is at once obtained. If not (and this has happened), the patient is not necessarily in a much worse condition than before, for the aperture made by the trephine is soon filled up by granulation.

Caries.

*Caries* is a term not limited by custom to any one diseased condition of bone. If an ulcer over the shin penetrate to the bone, it occasions inflammatory action on its surface, with some enlargement, and a state of spongy softening. The bone is carious. Again, if the cancelli of the tarsal bones take on a chronic strumous inflammation, leading to a thickening of their medullary membrane, and a morbid deposit in the cells, by which parts are necrosed, other parts suppurate, and the osseous texture becomes greatly altered in consistence: this too is caries. The latter form of disease is far the more important, and is always associated with a disorder of the constitution of a scrofulous kind. It attacks for the most part the irregular bones, which have a large quantity of the cancellated tissue, such as the vertebræ and the tarsus, and the same form of disease is common in the spongy extremities of the long bones. Its first progress is insidious, gradual, and not marked by much pain or swelling, the only symptom being some uneasiness in walking, or when the bone is in any way subjected to continued pressure. As the slow results of the inflammation become developed, swelling occurs from the participation of the soft parts, the periosteum, synovial membranes, and surrounding cellular texture, in the morbid action, the tenderness increases, the figure of the affected region is altered, its hollows are filled up, and it assumes the form of a rounded uniform tumor. Meanwhile matter is being deposited either in the cancelli of the bone, or in the neighbouring structures, or in both, and abscesses appear and open on the surface by ulceration. Portions of the cancelli also perish, and the joints are destroyed. This condition of parts may continue a very considerable period, without amendment or deterioration; and if the general health is such as to withstand the sappings of the disease, anchylosis may occur between the affected bones, the dead tissues may be evacuated, and the morbid action in those that remain may gradually pass into an inactive state, and the patient recover after many years, without the loss of the limb. But unfortunately this cannot be said to be the common course of this serious affection. The health becomes in general too much undermined to warrant hopes of the life of the patient being preserved, unless the system also be relieved from the morbid influence of the disease. Under these circumstances, it becomes the surgeon's duty to counsel the removal of the part. If the affection be of small extent, limited to a particular bone, and superficially situated, incisions should be made upon it, so as to expose it entirely to view, and all that can be removed is then to be chiselled or scraped away, and a surface of healthy bone left to granulate and heal, which it will readily do, and thus cut short the misery and protracted anxiety of years.

Surgery. Caries.

But it too frequently happens that this circumscribed operation would be insufficient to exterminate the diseased parts, the affection being so general as to occupy the principal portion of some particular segment of a limb. There is then no alternative, if the general health be dangerously impaired, but to separate the entire part from the rest of the system. Accordingly amputations in the civil hospitals are performed for this disease in some or other of its forms more often than for all other causes combined. And yet modern surgery has to boast of a very considerable diminution in the total number of amputations, by reason partly of the more scientific treatment of the disease in its early stages, and partly of the partial operations which are now frequently practised in instances where it used to be thought necessary to sacrifice the whole limb.

### Of Burns and Scalds.

Burns and Scalds.

Burns and Scalds are among the severest injuries that can be inflicted on the body, and from their peculiar nature have generally received special attention from writers on practical surgery. They differ from one another chiefly in the depth of the parts affected by them, burns often destroying the entire skin, and even the textures subjacent to it; while the effects of scalds are confined to the surface to which the heated liquid is applied. These varieties of injury may, however, be conveniently spoken of together. The immediate effect of heat applied to the body is a smarting pain, soon followed by a redness, and if the temperature has been at all high, by the formation of vesications, the cuticle being raised from the true skin by serum poured out by the excited vessels of that structure. A still greater heat will destroy the vitality of the integument, and reduce it to a blackened mass. Any of these degrees of injury, if confined to a small spot, are trivial; but they become dangerous and fatal by their diffusion over an extensive surface of the body. In the latter case they arouse wide-spread inflammation, and corresponding constitutional symptoms, and interfere besides with the function of one of the most important secreting organs in the œconomy. Thus a superficial scald of the whole body proves as rapidly fatal to life as a burn involving a much greater destruction of tissue, provided it be of limited area.

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Surgery.

Burns and Scalds.

Those burns that seriously affect the constitution may be termed *constitutional*, in contradistinction to those that are chiefly important from their topical effects, and which may be styled *local*. We shall briefly consider these in order. Collapse, sudden and extreme, follows an extensive burn as certainly as it does the tearing of a limb from the body. The sense of cold is exceedingly remarkable, and often seems to engage the whole attention of the sufferer: the countenance is pallid and terror-stricken, and the voice wild. Vomiting very generally supervenes if there is any attempt at re-action, and this vomiting will recur again and again, and is at once excited by whatever enters the stomach. If these symptoms continue several hours, the patient cannot survive, but dies from the effects of shock, with more or less attempt at re-action. To a person under these circumstances, ammonia, opium, and wine are indispensable from the first, and should be administered in small quantities and at frequent intervals, and, if necessary, be thrown into the large bowel in the form of enema. They soothe the nervous system, and encourage a revival of the drooping energies of life: it is needless to say that warmth must be added to these. The topical application to be made in such cases will consist of oily substances, which are the most agreeable to the patient. In less extensive burns, attended with destruction of skin, but without very severe constitutional symptoms, much difference of opinion did and does prevail as to the local treatment most suitable. The stimulant plan, known as that of Kentish, of smearing over the burnt parts a liniment containing turpentine, has received the sanction of general experience, and is the one most followed in this country. An extraordinary relief from pain is often known to ensue on this application being made, and it is supposed to expedite those processes which end in the detachment of the dead from the living parts, by stimulating the vessels of the latter: there is no doubt that turpentine will penetrate through a hard dry slough of the integument. In all instances the element will have acted with varying intensity on different parts; and while some will have been completely scorched up, others will have been only singed, and the cuticle raised in blisters. These last will have to be treated in a different manner. If the vesications be large, they may be snipped; but the epidermis should be permitted to remain, as it forms the most appropriate covering to the excoriated surface beneath. Over this, and such parts as may have been deprived of it, the best application is a mixture of oil and lime-water, which admits of being easily smeared on with a feather, and renewed without disturbance to the patient, or simple cerate may be spread on lint, and confined by bandages. These methods of treatment will apply respectively to burns of slighter extent. Cold is quite inapplicable to all large burns, from the depressing influence it exerts on the entire system; but it may sometimes be advantageously employed as a remedy in slight burns of the extremities. It is inadmissible on the trunk of the body in this as in most other cases.

Death may occur either before re-action, or from the secondary consequences of the injury during the inflammatory stage in the wounds, or from certain internal complications arising out of it; or, lastly, in the course of weeks, or even months, from the slow advance of debility, hectic, and colliquative diarrhœa, the effects of protracted and profuse suppuration from the sores left after the separation of the sloughs. Bronchitis and diarrhœa are not unfrequent precursors of death at the early period mentioned, and their accession has been commonly assigned to the vicarious activity of those surfaces, induced by the interruption caused to the cutaneous function. But though the truth of this explanation may be doubted, it may serve to evince the importance of keeping up the secretions of those membranes by suitable medicines. Where the person has been enveloped in flames for some moments, some of the flame may have been inhaled, in which case it will have scorched the mouth and glottis, and necessarily have excited inflammation capable of penetrating along the bronchial surface. Ulcers in the duodenum have been found in many cases of death after recent burns, and in some instances these have been the occasion of death, by opening the artery running between that intestine and the pancreas; but what may be the connexion, if any, between these ulcers and the burn, does not yet appear. It has been remarked by those who have had large opportunities of witnessing the terrible effects of fire on the children of the poor, who fall victims to it in great numbers every year in our large towns, from the imperfect care of their parents, who are engaged in the manufactories, that the issue depends in no small degree on the situation or region of the burn. Those of the trunk are, *cæteris paribus*, more dangerous than those of the extremities, and those of the back than those of the front of the body; the reason whereof appears to be this chiefly, that the means of relief cannot be so well applied and retained on one part as on another, and that certain burns mechanically interfere more with the processes necessary to life. A patient with an extensive burn on the back cannot rest or sleep except in an unnatural posture, and soon becomes exhausted.

Ulcers remaining after burns.

The ulcers remaining after burns that have been attended with great destruction of the cutaneous texture, are often very intractable. It is in these large suppurating surfaces that the inter-dependence of local and constitutional conditions is best exhibited, and most necessary to be closely watched, with the view of determining on treatment. Exuberant and florid, or flabby and pale granulations, co-exist with and respectively mark strength or debility in the powers of the system; and the ulcerative or sloughing process, from time to time recurring without any obvious local cause, sufficiently attest some fault in the nutritive functions of the whole body. On the other hand, the weakness, the hectic, the diarrhœa, the pulmonary disorder, which are so frequently the forerunners of dissolution in the course of these protracted ulcers, are themselves generally the consequence of the drain of the system from the sores. These are cases where the efforts of nature are especially to be seconded by art: there is no disease to combat, only the reparative action has to be sustained. For this purpose the constitutional symptoms are to be treated as they arise, regard being paid to this general rule, that all the functions should be preserved in as healthy a state as possible. In the local treatment a great variety of remedies have been employed, far too numerous to mention. They act on the principle either of excluding the air, or of protecting the newly forming skin, or of stimulating or enfeebling the action of the sore. Among them are chalk, calamine powder, lotions of alum, sulphate of zinc, or nitrate of silver, simple lint used as a compress, &c.

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Surgery.

Cicatrices left after burns.

The cicatrices left after burns are very prone to contract and to deform, or render useless the parts of the body on which they are situated. Thus cicatrices on the neck will drag down the cheeks and under-lip, so as to expose the cavity of the mouth; the eyelids may be permanently everted, the flexures of the joints made rigid, the fingers or the whole hand puckered up by these consequences of so great a loss of the healthy structures; and but little can be done to avert these lamentable occurrences. They depend on an interstitial absorption of a portion of the substance of the cicatrix, so that what remains is not sufficient to cover the surface, and the surrounding parts are drawn in to make good the deficiency. During the healing, such a posture may be preserved as may have the effect of moulding the contraction to the most convenient direction; and it is sometimes possible, by incising or cutting out old and rigid cicatrices, and healing them anew with more attention to position, to correct deformities both unseemly and disabling.

### Of the Effects of Cold.

Effects of cold.

These vary much with the powers of resistance in different persons. The natives of tropical countries will suffer from a degree of cold which those of colder regions ordinarily experience; and persons debilitated by want of food, by fatigue, or other causes, will be less able to bear a low temperature than those who generate much animal heat, and are provided with the means of economizing it by proper clothing. The benumbing effects of cold on the whole system are manifested by torpor and somnolence; and these, if allowed to gain ground, lead to a complete indifference to life, under which the unfortunate sufferer blindly lies down to sleep, never afterwards to awake. The instance of Dr. Solander is well known, who, on an excursion into Terra del Fuego, after warning his companions not to yield to the inclination to sleep, which he foresaw the intense cold would occasion, was the first to give way to its irresistible influence, and was only saved by the persevering exertions of his comrades in urging, and even compelling him to walk. This deep sleep is apparently the consequence of congestion of the brain.

But the local effects of cold are those which most frequently come under the attention of the surgeon. Parts of the body exposed to cold, such as the extremities, the nose or ears, become at first of a dull red colour, from the atonic dilatation of the small vessels, and the accumulation within them of the blood, which is at the same time impelled more feebly by the central organ. A further degree of cold will drive this blood from all the smaller vessels, and occasion a great diminution in the size of the part, which then becomes deprived of feeling and motion, and may be actually frozen, though this happens far less often than is imagined. The part thus affected may be destroyed, but more often vitality will return with returning warmth, and a restoration of the circulation. This re-action is very prone to run on to an excessive degree, and to be converted into inflammation, having a tendency to terminate rapidly either in vesication or sloughing, according to the amount of the previous cold. To prevent these consequences, the utmost care is required not to allow re-action to be completely established until the tone of the affected vessels shall have been, in some measure, restored; and this is best secured by applying warmth very gradually by frictions with snow or snow-water in the first instance, and afterwards by warm flannels. The temperature of the parts, when regained, should be preserved uniform by fomentation; or if sloughs are forming, by poultices, which are to be continued until the dead parts separate, the sores being afterwards treated as usual. The complaint called chilblain is the result of often-repeated exposure to cold not excessive. The fingers or toes are swollen, and of a dull red colour, the vessels having become dilated, and retarding the flow of blood. These may advance to suppuration in consequence of undue re-action following any unusual exposure, in which case they are to be poulticed; but in general they are to be rubbed from time to time with stimulating embrocations, with the view of restoring the healthy contractility to the minute blood-vessels. Regular and brisk exercise, and sufficiently warm clothing, with a nutritious diet, are the best preventives against this and other disorders arising from external cold.

Surgery.

Effects of cold.

### Of Hernia.

Hernia.

Hernia is understood to mean, the protrusion of any viscus from its natural cavity; but the term, when used alone, in the ordinary language of surgery, is limited to protrusion from the abdominal cavity, such being infinitely the most frequent. Traumatic hernia from the cranial cavity has been already spoken of; and hernia of the lungs may take place, in rare instances, through the walls of the thorax; but the physiological construction of the latter cavity is such as to predispose against this protrusion, there being ever a tendency for parts on its exterior to be drawn into it, rather than for its natural contents to be forced out. On the contrary, the abdominal viscera are constantly pressed upon on all sides by the walls which enclose them. Nothing can enter this cavity except by a direct extraneous propulsion, as when the food is driven forwards into the stomach by the rapid peristaltic action of the gullet; but the compression continually exerted by the parietes on the viscera is a never-ceasing cause tending to produce their expulsion at any point weaker than the rest. Now, the abdominal walls are of very unequal strength, being formed partly by bone, and partly by muscles with their tendons, but in such a manner as to allow certain structures naturally to pass though them in determinate situations. It is almost invariably at such natural apertures, or passages through the walls, that the viscera are found to protrude. Sometimes there is a predisposition to hernia in the special original conformation of the parts, which may be favoured by all causes known to affect the healthy development and nutrition of the fœtus or infant. Even where there may be no herniæ existing, considerable varieties in the strength of the defences at the various apertures are met with, and are well known to all conversant in dissections. But the most common occasion of herniæ is to be found in the undue straining and pressure to which the abdominal viscera are subjected in the pursuit of laborious employments in large towns, where the natural powers are but too often over-taxed. Frequent repetition of this will by degrees stretch and dilate the parts, until at length a sudden effort will thrust the viscus lying next the weak point among the structures forming the wall, or through them, so as to form a subcutaneous tumor.

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The viscera usually thus protruding, are those which lie loose and freely moveable in the cavity—viz., the intestines and omentum; but sometimes the bladder, or an ovary, may be found in the tumor. The consequences may be so slight as to be overlooked by the patient, because it is possible for the functions of the part to continue to be regularly performed, notwithstanding its displacement; but, on the other hand, they may be so severe as to prove speedily fatal if these functions are interrupted. If a viscus lie freely in the hernial tumor, and admit of being replaced by making pressure on its exterior or otherwise, it will transmit the fæculent matters as well as if it remained within the abdomen, and the hernia is then called a *reducible* one. If there be little or no obstacle to the performance of its office, and yet it cannot be returned into the abdomen, in consequence of adherences which it has contracted to the wall of the new cavity in which it lies, the hernia is termed *irreducible*. But when the function of the protruded organ is completely arrested, and the circulation through it is obstructed by a constriction of the passage through which it has escaped, the hernia is said to be *strangulated*, and the danger to life is imminent as long as this condition remains. A hernia may exist for years without any strangulation taking place, and, provided proper precautions be observed, may be borne with impunity throughout life; but accident or unforeseen causes may at any time occasion strangulation, and put a speedy termination to life.

The subject of abdominal herniæ has received extreme attention, and the most ample illustration at the hands of modern surgeons; and the beneficial results flowing from their labours in this important field are among the greatest triumphs which science has achieved. The anatomical construction of the abdominal walls, particularly at the points where herniæ are prone to occur, and the changes which they undergo by the presence of protrusions of this description, have been studied and described with the utmost precision and truth; while, from the knowledge thus gained, valuable practical rules have been deduced, which have greatly diminished the mortality from this very common disease. The limits prescribed to us will only allow of our touching, in a summary manner, on the general features of this extremely important subject, for a fuller account of which we would refer the reader to the classical works of Scarpa and Astley Cooper.

The viscera floating in the abdominal cavity are covered by the smooth and shining serous membrane, termed the peritoneum, which is reflected from them to line the abdominal walls, these layers being respectively styled the *visceral* and the *parietal*. Now, as the parietal layer passes over the weak points through which the viscera protrude, and is a very extensible tissue, it is pushed before them as they make their road outwards, and becomes expanded by them, and converted into a bag, in which they lie free, as they did before in the abdominal cavity. This bag is called the *hernial sac*: it consists of a process of peritoneum. Having got beyond the narrow orifice of exit, the viscera have room to expand, and they dilate the sac, leaving it narrow near the orifice, which is termed its neck. The peritoneum is attached to the tendinous and muscular structures of the parietes by a lamina of dense and very elastic fibrous tissue, which at the lower part of the abdomen, where hernia usually occurs, is considerably stronger than elsewhere, and constitutes a very distinct proper membrane, termed in front *fascia transversalis*, and behind *fascia iliaca*, from the muscles of those names on which it respectively rests. This fascia is pushed before the peritoneum in all herniæ, and becomes a covering immediately investing the hernial sac. It is more distinct in some varieties than in others, and in old than in recent herniæ, from the thickening it gradually undergoes by pressure and irritation. It may be termed, in all cases, the *fascia propria*. The other coverings of hernial tumors vary, and must be spoken of under separate heads.

In some rare instances there is a hernia with an incomplete sac, the protruded viscus having, in its natural situation within the abdomen, but a partial investment of the serous membrane. Thus the cæcum, as it lies in the iliac fossa, has no serous coat behind, but adheres by cellular tissue to the iliac fascia; and when it slides out of the abdomen, it remains attached in the same way by its posterior surface, and the sac is deficient there. A similar condition usually exists when the bladder protrudes.

The size of herniæ is liable to the greatest variety: some are so diminutive as to implicate only a part of the circumference of the small intestine, and to entirely escape detection; while others may be so capacious as to comprehend, in their ample dimensions, almost the whole of the abdominal contents. Small herniæ are more dangerous than large ones, because they are more apt to become strangulated, the neck of the sac being very narrow, and because they may be so easily overlooked.

Herniæ that pass out above Poupart's (or Fallopius') ligament, in connexion with the inguinal canal, and the apertures provided for the spermatic cord and its attendant vessels, are styled *inguinal*, and are the most common of all. When they are situate below Poupart's ligament, and bulge into the thigh, they are styled *femoral* or *crural*: these stand next in the order of frequency. Those emerging at the umbilicus are named *umbilical*; and if at any other part of the anterior wall, the general title of *ventral* is assigned to them. There are also *diaphragmatic*, *perineal*, *vaginal*, *obturator*, and *sciatic* herniæ, which receive their several designations from their points of eruption, and are all too rare to deserve more than a passing allusion in this place. Our principal observations will be directed to the inguinal and femoral varieties, as being by far the most important.

The inguinal canal is a narrow passage situated obliquely between the layers of the abdominal muscles, immediately above Poupart's ligament, and taking the sloping direction of that structure. It is the natural way down which the spermatic cord in the male, and the round ligament of the uterus in the female, take their course out of the abdomen—we mean, out of the fascia transversalis, and the muscular parietes of the cavity, and not out of the peritoneum, which is entire, and has no aperture at that part, but covers over that spot as it does every other. This canal is not a tube, but an interval between certain flat muscles, bounded below by Poupart's ligament, which forms for it a kind of grooved floor, on which the contained structures rest. Its deep orifice is placed further from the middle line of the body, and rather higher up than the outer one; and both orifices are termed *rings*, inappropriately enough. The deep or internal ring is opposite the centre of Poupart's ligament, and just above the external iliac artery,

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Surgery. Inguinal hernia.

which at that part gives off the epigastric artery, a vessel of considerable size, that, after its origin, takes an upward course on the *inner* side of the ring towards the epigastrium, to supply the rectus muscle. The vas deferens (or the round ligament of the uterus, as the case may be), coming up out of the pelvis, crosses over the external iliac artery just above the epigastric vessels, and is thus, of course, brought to the outer side of the latter. It then changes its direction, curves round the epigastric artery at or near its root, and enters the inguinal canal, thus getting immediately in front of that vessel. This arrangement is constant, and most important in reference to the question of making incisions for the dilatation of the internal ring in cases of stricture, so as not to wound the epigastric artery. The older surgeons, when they ventured to operate at all, did so doubtingly and with a dread of hemorrhage, which they did not know how to avoid nor how to arrest; but the surgeon now possesses a cardinal rule, which cannot fail to ensure immunity from so dreadful an occurrence. In the male the spermatic artery and veins descend along the loin, towards the internal ring, and then, after passing a little way upon the external iliac artery, meet the vas deferens on the outer side of the epigastric, and join it in its further course in the canal. They together form the spermatic cord, and are connected by areolar tissue. Ere they unite, the constituents of the cord are close to the peritoneum, between that membrane and the fascial tunic that invests it, and already spoken of. On uniting at the ring, and descending along the canal, they carry with them a funnel-shaped process or prolongation of this fascia, and do not burst through it; so that the cord in the inguinal canal is immediately covered by a fascia derived from the fascia transversalis, and called the internal spermatic fascia. Directly over the upper orifice of the inguinal canal arch the lower fibres of the internal oblique, and transversalis muscles of the abdomen as they leave their origin from the middle of Poupart's ligament; and having passed over the cord, they dip down behind it in the form of a thin tendinous sheet, and are then attached to the brim of the pelvis and crest of the os pubis, forming the posterior wall of the canal. Towards the internal ring, however, the back part of the canal is formed solely by the fascia transversalis. The cord lying in front of this tendinous sheet is covered over by a series of muscular fasciculi arising from Poupart's ligament, and called the cremaster. These pass down upon it to the scrotum, and, forming successive loops, return to the canal behind it, to be inserted into the pubis. They constitute an investment to the cord, separated from it only by the fascia spermatica interna already mentioned. On the cord thus covered rests the flat tendon of the external oblique muscle of the abdomen, of which Poupart's ligament is, in a great measure, the lower boundary. This tendon, therefore, forms the anterior wall of the canal, and the passage lies between the internal and external abdominal muscles. The outer orifice, or the external ring, often called *the* abdominal ring, is formed by the tendinous bands opening out to allow the cord to pass. Where the bands begin to separate, they are bound together by arched fibres (inter-columnar fascia), and they then diverge to two points of bone about an inch apart, the angle and the spine of the pubes. Thus the external ring is triangular, and cannot be contracted by any muscular action. This ring is covered over by the superficial fascia of the abdomen, which adheres to its borders, and sends down from them upon the cord as it emerges, a fibro-cellular covering, mingled with some of the inter-columnar fascia, and called the external spermatic fascia. This rests upon the cremaster. In the female the cremaster does not exist, and this fascia accompanies the round ligament to the fibrous structure over the pubes, where it is lost.

Varieties.

There are four varieties of inguinal hernia. In the first, the protrusion takes the course of the cord, and has precisely the same coverings as far down as it extends: this is *oblique* inguinal hernia, and is of all the most common. The spermatic vessels are behind the sac, and the neck of the sac is at the internal abdominal ring. The second bursts through the transversalis fascia, and the conjoined tendons of the internal oblique and transversalis muscles, and enters the canal opposite the external ring, after which it passes through that ring. Its coverings differ: it has no investment from the cremaster, which remains upon the cord behind and to the outer side of the hernial sac. This is *direct* inguinal hernia. The third is a sub-variety of the first, and is called the *congenital* hernia. In the early fœtus the testis, with its vessels, is placed within the abdomen on the psoas muscle, below the kidney; and it is gradually brought down into the scrotum about the period of birth, by a muscular structure, styled the gubernaculum testis. While in the abdomen, its front and sides receive a covering from the general expanse of peritoneum, and as it descends through the inguinal canal it carries down this covering, and drags down the peritoneum in the form of a tubular prolongation. This tube usually becomes obliterated, detaching the serous covering of the testis (now tunica vaginalis testis) from the peritoneum: but occasionally the communication between the two remains open, in which case any of the viscera may descend into the tunica vaginalis as into a hernial sac. This form of hernia commonly occurs in early life, but it may present itself for the first time at as late an age as thirty, if the tubular process have been previously very narrow, and have been then suddenly dilated by unaccustomed pressure on the viscera. Its nature can only be determined with certainty by finding the testis in the sac at the time of operation. The fourth, or *encysted* hernia, is rare, and consists in the sac descending behind the tunica vaginalis, which in such cases contains fluid.

Femoral hernia.

*Femoral* hernia is situated in the upper and front part of the thigh, below the inner extremity of Poupart's ligament. It protrudes through the crural ring, an aperture behind Poupart's ligament, in front of the os pubis, to the inner side of the femoral vein, and to the outer side of Gimbernat's ligament. This aperture is covered over by the transversalis fascia dipping into the thigh upon the femoral vessels to form their sheath. It is perforated by a number of large holes, for the passage of lymphatics from the inguinal glands, and often contains one of these glands. By these circumstances it is rendered a weak support against pressure from within, and where the arch of the pubes is ample, and the aperture wide, as in women, it very commonly proves incompetent to retain the viscera, and they bulge through it on any unusual muscular effort. Immediately below the ring, the fascia lata of the thigh, a dense aponeurosis which invests the muscles, presents a peculiar arrangement, to allow of communications between the vessels, on the superficial and deep surfaces



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Surgery. Femoral hernia.

of it. The saphenic vein, which runs up the inner side of the member in the subcutaneous texture, dips in about an inch and a half below the crural ring to join the great femoral vein, which pursues its course underneath the fascia lata. This latter structure is thus divided into two regions—an outer or iliac, and an inner or pubic. The former passes over the vessels, and is united to Poupart's ligament, sending a narrow triangular process (falciform), that comes to a point near the spine of the pubes: the latter dips under the femoral vessels. Thus a narrow slit exists in the fascia lata, just below the crural ring, and reaching as far as the saphenous opening. Femoral hernia, protruding through this ring, has first a covering from the fascia transversalis; then at once pushing aside the gland and lymphatic vessels, comes into the subcutaneous fascia that lies in the slit, and which is here thick, and separated into many laminæ by fat, glands, and small vessels, and hence termed *cribriform*. It distends this over it, and then is subcutaneous.

Femoral hernia bulges equally in all directions from the position of the crural ring, where its root or neck is situated. If large, it mounts over Poupart's ligament, but can be distinguished from inguinal by our being able to move it downwards below that structure, while the inguinal varieties, though they descend into the scrotum, yet have their root above Poupart's ligament. The spine of the pubis, being a subcutaneous bony tubercle, is the best guide, in circumstances of doubt, to the exact position of Poupart's ligament. It is of the utmost importance to distinguish these two forms from one another, both for our guidance during attempts at reduction, and particularly during the operation, should that proceeding become necessary.

Hernia is apt to be mistaken for various other affections, especially in the region of the groin. Some cases are essentially obscure. One great characteristic of a hernial tumor is its disappearing entirely under pressure; but this is wanting in irreducible and strangulated herniæ; most herniæ have an elastic, soft feel; but strangulated ones are generally very firm, especially if small. Hernia are always fixed deeply to the point of emergence; but other tumors may have a similar deep attachment. But under differing circumstances, various accessory symptoms will probably arise, which will aid the diagnosis. Such are interruption to the functions of the abdominal viscera, and many others.

When strangulation occurs in a hernia, the patient is at once placed in a condition of great danger. The causes of strangulation are usually sudden exertions of the body, in which the trunk has to be fixed by a great muscular effort, as in lifting heavy weights; and occasionally, distension of intestine already protruded, by flatus or feculent matters. The seat of stricture is at the neck of the sac, that is, either at the internal or at the femoral ring, or, in direct inguinal hernia, at the conjoined tendons. The neck of the sac itself may form the constriction, for it becomes dense and thickened by age, and remains elastic, allowing of sudden distension, but returning to its original size when the pressure is removed. All these circumstances are of great consequence in the proper treatment of the disease. The symptoms of strangulated hernia are to be distinguished into two kinds,—those arising from mechanical impediment to the natural functions of the incarcerated viscera, and those resulting from congestion and inflammation. Among the former are colic, dragging pain in the belly, obstinate constipation, followed by vomiting, obstinate and severe, first of the contents of the stomach itself, then of bile, and the matters contained in the parts of the intestine above the hernia, or as far down as the valve between the small and large gut; for nothing can pass upwards through that valve. With these are great despondency, anxiety, and tormina, and the pulse is small and rapid. The hernial tumor itself is the seat of great pain, stretching towards the back; it is tender, swollen, and hard, from the inflammatory action that supervenes in the intestine and the sac, and the consequent suffusion of serum. If nothing be done to relieve the stricture, the intestine mortifies, inflammation spreads to the peritoneum, with the symptoms belonging to that affection, and the patient, except in rare instances, perishes. Sometimes the gangrene is confined to the strangulated portion, and lymph is effused, which glues together the surrounding viscera, shutting off the disorganized part from the rest of the peritoneum. The dead part, on separating, may then be carried down the canal and be evacuated by stool, while the continuity of the tube is restored, at first through the cavity formed by the slough, and, finally, by the contraction and healing of this, and by the approximation and union of the ends of the remaining sound intestine. These latter phenomena may occur with or without the escape of fæces outwards, by a slough over the hernia, forming an aperture called an artificial anus; but they are too uncommon to be other than exceptions to the general fatal result, and do not influence the practice of the surgeon in strangulated herniæ in the slightest degree. This reparative power of nature has, however, been studied and turned to great account by modern surgeons in the treatment of wounds of the intestine.

Surgery. Strangulated hernia.

When the symptoms of strangulation supervene, all the efforts of the surgeon are at first directed to return the part into the abdomen. Pressure with the fingers, technically called the *taxis*, aided by suitable posture, and by the knowledge of the anatomy of the parts will frequently succeed, if used early, and it may be seconded by venesection, the warm bath, the application of cold to the tumor, and the exhibition of enemata of cold water, or of some stimulating or narcotic substance. If these means fail, the operation of dividing the stricture should be resorted to. In young persons, where the symptoms are violent, no time is to be lost, but in old subjects, who have suffered from hernia long, where the sac and its neck are long, and where the symptoms have been occasioned by flatus or fæcal accumulation, more delay may be admitted of, and less summary measures be pursued.

The operation being determined on, the patient is placed on his back, and an incision is carried through the skin on the tumor, sufficiently large to expose its interior, and to give room for the surgeon's fingers to readily reach its neck. In inguinal herniæ this is usually made straight, but in the crural variety the object is best answered by making it ⊥-shaped. The several layers are divided with care, either by using an ordinary forceps and scalpel, or by insinuating a grooved director under each, and slitting them up with a blunt-pointed bistoury. The sac is generally known by its dense and bluish aspect, and on being punctured, in most cases gives issue to more or less serum that has exuded from the congested bowel within. The sac being now freely opened, the operator proceeds to examine the nature

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and state of its contents. There may be omentum or intestine, or both, in which last case the omentum lies in front so as to conceal the gut. These structures will present various appearances, according to the tightness and duration of the stricture, and the amount of inflammation that has supervened. A dark livid colour of the intestine is to be expected, as the necessary consequence of the turgidity of its vessels; and if not intermingled with greenish half-flaccid spots, which denote gangrene, is not to be regarded as itself an unfavourable sign, and the stricture is at once to be relieved. This is to be effected by passing the finger, or, if that be impracticable, a deeply-grooved and winged director within the neck of the sac, and dividing it to a slight extent. If it be an oblique inguinal hernia, the direction of the knife must be upwards and a little outwards, to avoid wounding the epigastric artery; if a direct inguinal hernia, it must be carried upwards and inwards, for the same reason, and if a femoral one, directly upwards. The general rule laid down by Sir A. Cooper, of cutting directly upwards in all instances, is plain and easily remembered, and, with common care, cannot fail to be successful. The protruded part is then to be returned into the abdominal cavity, the integuments brought together by sutures, and a light compress placed over the part to prevent a recurrence of the protrusion.

If the bowel found in the hernial sac be already in a gangrenous state, it would be unsafe to return it, because its contents would in all probability escape into the peritoneum before the neighbouring parts of that membrane had been glued together by lymph. It must therefore be left in the sac after the stricture is divided, and an incision may be made through the sphacelated spot to give vent to the accumulated matters; a proceeding frequently attended by almost instantaneous relief. The subsequent progress of the artificial anus, thus established, is various, and depends much on the size of the orifice, and the position of the intestine in its vicinity. If small, it will give issue only to a part of the contents, and by its gradual contraction, aided by moderate pressure, will at length cause them all to pass along by the natural channel; after which the external orifice may close. When the slough has occurred at the convexity of a large knuckle, the two sides of the knuckle lie alongside and open together, and between them is a septum, formed by their coats, and which are more or less adherent to one another. This septum prevents the fæces from entering the lower orifice; and it becomes a great object to cut it through, so as to make the two pieces of intestine communicate deep in the wound and within the abdominal walls. For this purpose Dupuytren invented an instrument, the blades of which are passed up the gut on each side of the septum, and are then forcibly brought together, so as to compress and cut through the septum, without laying open the peritoneum. For this cavity, if it enter the septum, becomes obliterated by inflammation before the septum is destroyed.

It may happen that the intestine adheres to the sac by bands, the product of former inflammation. If these are few they are to be divided; but if the adhesion be extensive, the intestine must be allowed to remain in its place after the stricture has been relieved. The immediate effects of the operation are the same as they would have been had the protruded viscus been returned to the abdomen; but there is of course more danger for the future. When omentum occupies the sac, it is often doubtful how it should be treated. If, as often in old cases, it is thickened and indurated, it is to be cut off near the neck of the sac, and the bleeding vessels tied. Before dividing it, the surgeon must have it properly secured above, or it is liable to slip into the abdomen before the hemorrhage is arrested. This plan of cutting away diseased omentum is far better than that of strangulating it by the ligature. When the omentum seems healthy it may be pushed back into its site; but, under some circumstances, it may be advisable to leave it in the neck of the sac to become adherent, and serve as a plug to prevent future escape of the abdominal contents.

We have described the operation usually practised. There is another which consists in a division of the stricture without opening the sac, and which was proposed in order to avoid the untoward consequences which general opinion attributes in many instances to penetrating wounds of the serous membrane. The steps of the ordinary operation are performed until the sac is exposed, when the surgeon insinuates a director between the neck of the sac and the adjacent structures, and divides these with a bistoury in the usual direction. The taxis is then applied on the outside of the sac, as if no wound had been made. This operation is applicable to many recent herniæ, where there may be no apprehension of sphacelus of the intestine, and the most fear of serous inflammation. It must be regarded as an admirable improvement, calculated to diminish the mortality of the disease. It is no argument against it that the stricture is sometimes formed by the neck of the sac itself, as the old operation can be at once substituted for this one, when it has been found unavailing.

We have now described the treatment to be pursued in the case of a strangulated hernia. This treatment is the result of much thought and careful research among modern surgeons; and judicious and rational as it is, it must be regarded as at best a kind of *dernier ressort*, attended with grave chances against a favourable issue. This will show the extreme importance of noting the predisposing and exciting causes of herniæ, and of averting in time the disastrous results which too often inevitably follow strangulation. Trusses of various kinds have been invented for keeping up a continuous pressure upon the skin over the aperture through which protrusion occurs, and are among the most valuable apparatus of surgery. They consist usually of a pad, fixed by a steel spring, which passes horizontally round the body, and is generally kept in place by a tape under the perinæum. They should in all cases be adapted to the individual by a surgeon who understands the anatomy of the parts, and the precise direction in which pressure is to be made. Many trusses are worse than useless, by allowing the hernia to descend behind them, and to become subjected to their pressure. It is obvious that a person liable to hernia should abstain cautiously from everything that can occasion disorder of his alimentary canal; should never allow himself to be constipated, and should avoid all exertion of a violent and sudden kind. Trusses, if worn for two or three years after the first appearance of a hernia, will generally cause the complete cure of it; but if their use be not commenced for some time after the descent, there is less hope of this favourable result, and they must be continued many years, or throughout life.

Much more might be added on various points of this important subject; but we must be content with the



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Surgery. rapid sketch of its general bearings, to which our limits have confined us.

### Of Aneurism.

Aneurism. Aneurism is a disease of the very first consequence to the surgeon, because if unchecked it is necessarily fatal, and yet it may very often be cured by timely interference. Everything will depend on his judgment, promptitude, and skill. It consists in a cavity containing blood, and communicating with an artery.

True aneurisms are those formed of the dilated coats of the vessel; the false are formed wholly or in part by the surrounding textures, often lined by lymph. True aneurisms are the result of disease; the false often follow from wounds inflicted on the arterial coats. "Aneurism in its worst shape," says a great authority, "is a terrific disease. Aneurism of the aorta, for example, when occupying the chest, and pressing on its contents, the tumor pulsating with a blow like that of an engine, then rising visibly, gradually increasing, and suddenly bursting with a force that sends the blood to the ceiling! Again, in the extremities the tumor is with equal certainty fatal, if left without timely aid, and thereby imposes on the surgeon an extraordinary responsibility." If the disease have an external position, it appears as a tumor in connexion with one of the great arterial trunks, usually pulsating synchronously with the strokes of the heart, and having a soft compressible feel if it be filled with fluid blood, but firmer if there be much coagulum in the sac. There is generally an audible rush with each pulse, heard by applying the ear over the swelling; and on laying the hand upon it we feel a swell or distension, not only upwards, but in every direction, and can press out the blood more or less readily. Such are the marks of an aneurism in its earlier stage, and they may all be in some degree counterfeited by other diseases. A tumor adherent to an artery may derive pulsation from it; and if it be an encysted one, it may possess something of the swell of an aneurism, and by its compression of the vessel it may occasion the blowing or rushing sound (termed *bruit de soufflet*); but in general such affections may be distinguished from aneurism. It often happens that such tumors can be elevated a little from the artery by the fingers, and then the pulsation is found to have ceased; a characteristic sign. We shall not attempt to define minutely the distinctions of aneurisms, but content ourselves, as on other occasions, with a sketch of the main features of the subject.

The elastic or proper coat of the arteries is liable to a slow alteration of structure, whereby it is deprived of its toughness and elasticity, and suffers gradual dilatation by the force of the blood within it. This disease may exist without aneurism, however, provided the circulation is not very active, as may be constantly seen in old persons; but if it comes on early in life or in the vigour of manhood, while the heart beats with strength and frequently with vehemence, it makes the vessel unable to resist distension. Some arteries are particularly liable to dragging from their position, such as the popliteal and the axillary, and it would seem as though such arteries were more prone either to take on the morbid action or to suffer from its presence than others, for aneurisms of the extremities most commonly occur near the joints. When the dilatation has proceeded to some extent the coats of the artery give way, and the remainder of the sac comes to be formed of the neighbouring structures—bone, ligament, muscle, nerve, or within the great cavities of the trunk by some or other of the viscera—as the lungs. When an aneurism results from a wound or rupture of an artery, the blood is shed into the surrounding parts, and a recess among them is formed by degrees, partly by the coagulation of the blood in the meshes of the cellular tissue, and partly by the effusion of coagulable lymph from the capillaries. The inner surface of this *sac* grows smooth, and seems at length continuous with that of the artery, but blood is deposited upon it in layers, and always tends, more or less efficiently, to its obliteration. It has been observed that these layers sometimes encroach far on the cavity of the aneurism, and reduce its dimensions within very narrow limits, and in some very rare instances they have completely filled it, and thus spontaneously cured the disease. This fact is one of great significance—this tendency to coagulation of the blood that fills the sac, and which, be it remembered, is, like that within the vessel itself, in constant motion. That the blood should preserve its fluidity as long as it remains within its natural channels, and coagulate on its withdrawal from them, is one of the most wonderful provisions of the animal economy, and seems to depend simply on the lining of epithelium within the arteries and veins which we have before mentioned. This lining does not exist within aneurismal sacs, and thus coagulum is deposited there, notwithstanding the rush of blood through them.

The coagulation of the blood within the sac is also favoured by the slowness of its passage through it, and it would speedily obliterate the cavity could its motion be altogether stopped. There is therefore one principle to guide our efforts to promote this occurrence, and the carrying out of this in practice is called the method of Valsalva, who was the preceptor of Morgagni, and the first to inculcate it. The patient is to be starved almost to death, and depressing remedies given, so that the circulation may be as languid as is compatible with life, and compresses and cold are to be applied to the tumor, and if possible to the whole region where it is situate. This treatment is to be continued for weeks or months. It may be fairly questioned whether acting on the heart by digitalis or tartar-emetic, with perfect rest, and the use of the local measures above specified be not likely to be rather seconded than contravened by an animal diet, administered with a view to render the fibrine more abundant and more coagulable. In many large aneurisms of the chest, where the method of Valsalva has been the only available one, it has had the undoubted effect of retarding, and in some instances even of curing, this formidable affection.

But in the infinite majority of cases of aneurism this treatment is found to be of no real service in checking the progress of the disease. The sac increases in size, the structures in the vicinity are pushed aside or absorbed, until the sac gives way, blood is thrown among the textures, or it escapes into a cavity or through a slough of the skin, and the patient perishes in an instant. If the surrounding parts are infiltrated with blood inflammation commonly supervenes, and generally leaves no other chance of recovery than by amputation, if indeed that be practicable. To prevent these disastrous consequences an operation is to be performed, which modern surgery has introduced, and which is applicable to almost all aneurisms but those of the trunk;

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the artery is to be tied and obliterated between the disease and the heart. The idea of an obliteration of the main artery appalled the older surgeons, because they were not aware of the free communications everywhere existing between neighbouring branches, and which are wholly sufficient, after the main current is stopped, to carry along the blood required for the nutrition of the parts below. This anastomosis, as it is termed, of the collateral channels, is shown by the bleeding from both upper and lower orifices of a divided artery, and makes the surgeon fearless in applying a ligature to both. When a ligature is placed on the artery leading to an aneurism, the current of blood to the sac, therefore, is not quite stopped, but by becoming more circuitous its force is broken as it traverses the small vessels, and this gives the desired opportunity for coagulation to take place within the sac. After such an operation the sac soon beats as before, and the limb becomes warm, but by degrees the pulsations in the sac grow fainter and the tumor more solid, until the mass of coagulum is sufficiently large and firm to resist further distension, even though it do not quite fill the sac. But in general not only is the cavity impacted by it, but the artery is obstructed permanently near the orifice of communication by an extension of the clot into it. An admirable proof of the current continuing in the artery below the ligature is the fact, that a part of that vessel between the ligature and the sac may remain permanently open, receiving and transmitting blood through small branches. This often occurs where the artery is tied in the thigh for aneurism in the ham, the distance between the two points being greater than in other situations. This operation, which we owe to John Hunter, is one of the greatest improvements of modern surgery. It would appear that its author considered the great advantage of tying the vessel at a distance from the aneurism was, that its coats there were more likely to be healthy, and therefore to escape ulceration and secondary hæmorrhage. It is attended, however, with the further advantage of a small wound, and that at a distance from the seat of disease, so that inflammation is less likely to occur and to spread dangerously if it do supervene. It is clear that the extensive inflammation that used to follow the sanguinary operation of the old surgeons, of laying open the entire sac by a large incision, sponging out the blood, and tying the bleeding orifice in the vessel, was a frequent cause of the gangrene that so often made this proceeding the terrible forerunner of death.

The modern principle of cure has now been carried into practice in the case of all the principal arteries of the head, neck, and extremities, and even on the aorta itself, and its merits thus sifted in a great variety of instances. The result is, that if performed sufficiently early in the course of the disease, it is the safest and most certain curative measure that can be adopted in aneurisms of the arteries in the limbs, and of the carotids and their branches. The external iliac artery has been frequently tied with success for aneurism of the femoral, since Mr. Abernethy's first operation in 1796, and the internal and common iliacs in a few examples. The subclavian has also been tied in the outer and middle portions of its course for axillary aneurism, and in its inner part for aneurism of the vessel outside the scalenus muscle, as well as distally with the carotid, for aneurism of the innominata. The operation in this latter situation has never yet succeeded; the patients in whom it has been tried have lived long enough to prove that circulation was restored in the arm by collateral channels, but they have uniformly died previous to the separation of the ligature, either from inflammation within the thorax or from secondary hæmorrhage, arising from the failure of the reparative process in the artery. The same result has followed in sundry operations on the arteria innominata, and it appears doubtful whether this vessel or the subclavian in the first part of its course will ever be tied with success. Their very large size, and, in the latter case, the origin of several large branches near the point of ligature, seem to form obstacles too great to be overcome. Even the aorta itself has been tied in three instances, but with uniform ill success. John Bell had shown that this great trunk was sometimes obstructed by coagulum, or contracted, so as to give no passage to the blood, and yet that the inosculations between various branches above and below the impervious point were quite capacious, and free enough to convey the blood to the lower limbs; and Sir A. Cooper was so bold as to cut down through the belly and pass a ligature round this vessel in a case of iliac aneurism. The result showed that the circulation was not interrupted, though the patient died in a few hours.

The above facts abundantly testify to the inadequacy of this operation in certain cases. In these, however, the artery may sometimes be tied beyond the tumor, *i. e.*, further from the heart. This operation, proposed by Brasdor, was brought into notice by Mr. Wardrop. It has succeeded in a few cases of aneurism of the great arteries at the root of the neck. It is not, of course, so efficient in diminishing the rush of blood into the aneurismal sac as the operation of Hunter; but as it is applicable in some instances from which experience has excluded the other, it must be regarded as an important step in the surgical treatment of this disease.

We may here advert to the operation itself. The cutting down on a great artery and placing a ligature upon it, is a proceeding justly reckoned among the capital operations of surgery. The surgeon has not only to be accurately acquainted with the anatomical position and connexions of all the principal arteries, but must understand the process by which nature effects the permanent obliteration of the vessel. If ignorant on these points, he may easily sacrifice the life confided to his skill. The several textures over an artery having been cut through or turned aside, the cellular sheath in which it is enveloped is to be opened with a blunt-pointed instrument, as a probe or director, and the artery bared all round to an extent sufficient to admit the curved blunt needle carrying the thread. This needle itself is as good an instrument as can be employed for effecting this. The sheath once opened, the thread is easily slipped round the vessel; but if dense cellular membrane is left adhering to the artery, the needle is apt to wander from its course, to pierce the contiguous vein, or to encircle neighbouring nerves. The artery is to be separated from its sheath only as much as may be absolutely required for the passing of the thread, in order that the minute vessels that will have to conduct the reparative process may be preserved entire. For the same reason the thread should be round and not too thick, and it should be tied tightly, that it may crush the proper arterial coat, and be detached early. The usual period for its separation is from the fifteenth to the twenty-fifth day.

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The cure of aneurism by the operation of Hunter, although it is that which every surgeon is bound to attempt in the vast majority of cases, yet is attended with some dangers, and may possibly accelerate a fatal result. Gangrene of the limb comes on in a few instances, and secondary hæmorrhage may occur from a failure of the healing process in the artery. These untoward events will depend on a variety of collateral circumstances, and may be frequently obviated by proper precautions, and on the whole they form no argument against the performance of the Hunterian operation in ordinary cases

We have now spoken of the treatment of spontaneous aneurisms; it remains for us to say a few words on those aneurisms that result from injury to the arterial coats.

Aneurism at the bend of the elbow, from a wound of the brachial artery, inflicted by the lancet during venæsection, was formerly a disease more common than in the present day, when those who have this little operation to perform are better instructed in anatomy, and know how to treat a puncture of the artery if it occur. The veins proper to be opened in phlebotomy lie in the cellular membrane and fat subjacent to the skin, and termed superficial fascia. The artery runs below, and separated from them by the strong sheet of fibrous structure which invests and binds down the muscles, and which is called the deep fascia; so that the lancet must transfix the vein and the deep fascia before it can enter the artery. A most important rule, therefore, in venæsection is to distend the vein previously, and to puncture only its superficial wall. But occasionally the artery divides above the elbow into the two chief arteries of the fore arm, in which case one of these may pass down in the superficial fascia, with the veins, and be more liable to injury. Hence the surgeon should always endeavour, before thrusting in his lancet, to ascertain the precise position of the artery by feeling its pulsations. A puncture of the artery is at once known by the spirting forth of scarlet blood in furious jets, along with the dark even stream of purple venous blood. Seeing this, the surgeon must consider the direction of the puncture in relation to that of the vessel, and what may be its size. If very small, he should at once compress the part firmly, and having stopped the flow, should then bandage the entire limb from the fingers upwards, and enjoin the most absolute rest. In this way a few days will sometimes be sufficient to ensure a re-union of the wound without further bad consequences. But if the bleeding orifice be large, if it probably traverse more than a fourth part of the diameter of the vessel, these means are not to be trusted to, but an incision must be made down to the bleeding point, and the vessel secured with a ligature immediately above and below it. The after-treatment will be that of wounded arteries generally. When these means fail, or are not pursued, the patient may die of hæmorrhage primary or secondary, or if the external wound be healed rapidly ere that in the artery is closed, the blood may force itself from the artery through the contiguous orifice in the vein, and thus form a permanent channel of communication between them, which, if direct, is termed an *aneurismal varix*, the vein becoming dilated; but if through the medium of an aneurismal pouch established between the two vessels, receives the name of *varicose aneurism*. But more commonly the orifice in the vein is closed, and the pouch formed is an aneurism with walls constituted of the neighbouring structures lined by lymph and fibrine. A similar result may follow wounds of any other large artery of the body.

Cases of communication between the artery and vein are not to be interfered with unless great inconvenience results, or they tend to increase rapidly. The only operation admissible, where the vein is implicated, is to take up the artery above and below the wound. Hunter's operation will not succeed, but produce mortification of the arm; for the collateral circulation cannot be established through the capillaries, when there exists so direct a communication between the artery and vein. It previously required all the force of the arterial pulse to drive the blood through the capillaries of the limb below the orifice. In the false aneurism from a wounded artery, the aneurism may be opened and the vessel tied above and below; or Hunter's operation may be practised. In general the former course will be preferable. A tourniquet is placed on the limb, the sac is laid freely open, the coagula sponged out, and a probe set in the orifice, as it spouts forth its blood when the tourniquet is unscrewed. The threads are then passed round the vessel, taking care that its coats are not detached more than necessary from the sheath. The sac will suppurate and close up; but the motions of the joint will remain constrained if the tumor had attained a large size.

### Diseases of the Eye.

Diseases of the eye.

The eye, with its appendages, is subject to numerous diseases, which are especially interesting, on account of the delicacy and importance of the parts concerned, as well as from the fact that we are enabled to see the changes induced by these diseases, and to trace their daily progress with ease and accuracy. We shall consider first the diseases of the eye-lids and lachrymal apparatus, and subsequently those of the eye itself, and of the conjunctiva. Our account of this important class of diseases must necessarily be very brief.

*Hordeolum* or *stye* is a small painful tumor on the margin of the lid. It arises from obstruction and inflammation of one or more Meibomian follicles. It is best relieved by warm fomentations, and, when it is sufficiently advanced, by a puncture.

*Ophthalmia Tarsi* is inflammation with disordered secretion of the Meibomian glands. The secretion accumulates during the night, and the edges of the lids become glued together. It occurs in strumous persons, and is often associated with disorder of the digestive organs. It not unfrequently leads to loss of the eye-lashes. The general health must be attended to, and the bowels must be carefully regulated. The best local application is the diluted nitrate of mercury ointment, which may be rubbed on the margins of the lids. *Entropion* denotes an inversion of the eye-lid, and a consequent rubbing of the lashes upon the surface of the eye. This condition keeps up a constant inflammation of the conjunctiva, and an increased flow of tears. The remedies are, to make two perpendicular cuts with scissors through the margin of the lid, or to dissect away entirely the margin of the lid. Another mode consists in cutting an elliptical piece from the skin of the lid; the contraction of the cicatrix counteracts the tendency to inversion.

*Ectropion* is an eversion of the lid, which most commonly is the result of chronic inflammation and thickening of the conjunctiva; but it is sometimes produced by the contraction of a cicatrix on the cheek. If a thick-

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ened state of the conjunctiva be the cause of entropion, we must remove this by the use of stimulating and astringent lotions, or by the application of the sulphate of copper. When it appears to arise from an undue laxity of the entire lid, it has been proposed to remove a triangular piece from the margin of the lid. If caused by a cicatrix on the cheek, the cicatrix must be divided or dissected out.

*Lagophthalmia* is an inability to close the eye, in consequence, generally, of palsy of the portio-dura, which nerve supplies the orbicularis muscle.

*Ptosis* is a falling of the upper lid, from palsy of its levator muscle. It is sometimes the precursor of a fit of apoplexy, in other cases it results from palsy of the third nerve, by the pressure of a tumor or some other local cause. The treatment must be conducted with reference to the cause. If it persist after all other means have failed, a portion of skin must be snipped out from under the eye-brows, so that after the contraction of the cicatrix the lid may be raised by the occipito-frontalis.

*Closure of the lachrymal puncta* occasionally occurs, and produces stillicidium lachrymarum, or a flow of tears over the cheek. The openings may be restored by passing a very fine probe through the puncta. *Inflammation of the lachrymal sac* is known by the formation of a red, tender, and painful tumor by the side of the nose, and beneath the inner angle of the eye. The tears are prevented taking their usual course, and they flow in a constant stream over the cheek. If the inflammation be not subdued, matter forms, and escapes by an opening on the cheek. In some cases the bursting of the abscess is followed by the closure of the orifice and a complete cure; but it more commonly happens that some chronic inflammation remains, the mucous membrane of the sac and of the duct becomes much thickened, the passage of the tears down the duct is completely arrested, a fistulous opening on the cheek remains, and gives exit to the contents of the sac; or when, as sometimes happens, this orifice closes, the tears may be made to regurgitate through the puncta by pressure made upon the sac. In the early stage the object of treatment is to subdue inflammation by the application of leeches and the use of fomentations. If suppuration occur, the matter should be evacuated by a puncture, the sac may then be washed out by an injection of warm water, and afterwards a solution of acetate of lead or sulphate of zinc may be used for the same purpose. If, in consequence of the thickening of the mucous membrane, the nasal duct be obliterated, a silver style must be passed down the duct, the head of the style resting upon the cheek; the tears make their way by the side of the style, and the patient is freed from the annoyance of a constant flow of tears over the cheek. The style must be taken out and cleansed occasionally; the duct is very apt to close if it be left off, and it is generally worn for life.

The conjunctiva is subject to inflammation, which in different cases varies much in degree as well as in its consequences, and in the circumstances under which it occurs.

*Catarrhal ophthalmia* is that variety of inflammation of the conjunctiva which arises from exposure to cold and wet. It is attended with pain and heat in the eye, and a sensation as if particles of sand or dust were beneath the lid; the conjunctiva is of a scarlet red colour, the vessels are superficial, and can be made to move over the sclerotic. The secretion of the membrane is at first diminished, and there is a sensation of dryness; in the more advanced stages there is an increased mucous discharge, and in severe cases it becomes slightly purulent. The cure may be effected by the application of a few leeches, a calomel purge, followed by a black draught, and a saline diaphoretic. The most efficacious local application is a lotion of nitrate of silver, in the proportion of grs. iv. to ℥ j. of water. The margins of the lids should be smeared with simple ointment, to prevent their adhesion at night.

*Chronic inflammation of the conjunctiva* is frequently the sequel of the acute; if long continued it produces a granular state of the conjunctiva lining the lids, which acts as a constant source of irritation. This form of the disease is best treated by stimulants, such as the vinum opii, a few drops of which may be put into the eye daily. Blisters behind the ears are occasionally of use. The granular state of the conjunctiva may be removed by the application of the sulphate of copper.

*Purulent ophthalmia* in children occurs a few days after birth. In some cases it arises, without doubt, from the contact of irritating discharges to which the child is exposed during its passage through the vagina of the mother. In other cases there is no evident vaginal discharge, and we must attribute the disease to exposure to cold and neglect of cleanliness. It is attended with intense redness of the conjunctiva, great swelling of the lids, and a profuse purulent secretion; at the same time the child is restless and feverish. If neglected, it leads to opacity, ulceration, and even sloughing of the cornea; but it generally yields to early and judicious treatment. The bowels should be opened by hyd. c. cretæ with rhubarb; a leech may be applied to each lid, taking care that the bleeding be not too profuse; the eyes must be kept washed and bathed with warm water, and a solution of alum, in the proportion of grs. iv. to ℥ j. water, must be syringed into them twice a day. Purulent ophthalmia in adults is a more formidable disease; it occurs under two forms,—the contagious or Egyptian, and the gonorrhœal ophthalmia. The first form is that which has on some occasions spread very extensively among our armies. The crowding together of a number of men in close and ill-ventilated rooms seems especially favourable for the propagation of this disease, not merely by contact of the purulent secretion, but by infection through the medium of the atmosphere. The gonorrhœal ophthalmia is produced by the contact of the matter of gonorrhœa, and rarely attacks both eyes; it does not differ from the last-mentioned form, except in being more severe and more certainly destructive of the eye. Both these forms of ophthalmia commence with stiffness and a sensation as of a foreign body in the eye, the lids become much swollen, the conjunctiva intensely vascular; the great swelling of this membrane round the cornea is termed chemosis; the secretion is at first scanty, but it soon becomes purulent and very abundant; there are headache and fever. It frequently leads to ulceration of the cornea, and in the most severe cases it extends to the deep tissues, producing suppuration in the globe, sloughing of the cornea, and complete destruction of the eye. In order to arrest the progress of this rapidly destructive disease, blood must be taken from the arm, and from the neighbourhood of the eye by leeches or cupping; the patient must be kept on low diet and in a dark room, and the bowels must be

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freely purged. The local application, which, although formidable in appearance, has been attended with most success, is a strong solution of nitrate of silver, or the ointment recommended by Mr. Guthrie; this is composed of grs. x. nitrate of silver to ℥j. lard, and a piece the size of a pea is to be placed on the surface of the globe twice a day. When the chemosis is excessive, and threatens to obstruct the passage of blood to the cornea, incisions radiating from the cornea should be made down to the sclerotic. After the acute stage is over, blisters may be applied to the nape of the neck and to the temples.

*Strumous ophthalmia* commonly occurs in children. It is marked by great intolerance of light, not much vascularity of the conjunctiva, but some vessels are seen running towards one or more pustules on the cornea; these pustules generally lead to ulceration of the cornea, and sometimes to perforation, escape of the aqueous humour, and prolapse of the iris. The cicatrization of ulcers on the cornea generally leaves some permanently opaque spots, the slightest of which are called *nebulæ*, and the more considerable opacities have received the name of *leucoma*. A collection of pus between the laminæ of the cornea is called *onyx*, from its resemblance in shape to the white spot at the root of the finger nail. In the treatment of strumous ophthalmia attention must be paid to the general health. The bowels must be carefully regulated, tonics may be given, the application of a few leeches is sometimes useful; blisters to the nape of the neck and to the temples, and a solution of nitrate of silver, or the vinum opii, may be applied to the eye daily. *Inflammation of the sclerotic* is called rheumatic ophthalmia. In this form of inflammation the redness is deep-seated and of a pink hue; the vessels radiate in straight lines from the cornea; there is considerable dimness of sight, and great pain, which is not confined to the eye, but extends to the forehead, and is much aggravated at night. The treatment consists in bleeding and leeches, purgatives and diaphoretics; sometimes calomel and opium; Dover's powders and opiate liniments over the brows to relieve the nocturnal pain. *Inflammation of the iris* is characterized by intolerance of light, dimness of sight, a zone of pink vessels surrounding the cornea; lymph is effused, rendering the fibres of the iris indistinct, and changing its colour; sometimes the lymph is seen in the form of minute drops on the surface of the iris; the pupil becomes small and irregular, and is occasionally completely closed by the effused lymph. Iritis may be the result of a wound, but it generally arises from a syphilitic, gouty, or rheumatic state of the constitution. In the treatment blood must be taken from the arm, or from the neighbourhood of the eye, by leeches or cupping, according to the severity of the case and the strength of the constitution. Calomel and opium must be given to affect the mouth, and thus to promote the absorption of lymph, or to prevent its further effusion. Another important point is to keep the pupil dilated with extract of belladonna, a solution of which should be smeared on the brow or dropped into the eye. Turpentine is a valuable remedy in iritis, and may be used when from any cause mercury is deemed inadmissible. In gouty and rheumatic iritis mercury is less important and less requisite than in the syphilitic form of the disease. When the sight is impaired by closure of the pupil, or by an opacity in the centre of the cornea, an artificial opening may be made in the iris. This may be done by introducing a cutting needle through the cornea and making an incision through the iris; or an incision may be made in the cornea, the iris drawn out with a fine hook, and a portion snipped off; the latter is the preferable mode.

*Cataract* is an opacity of the crystalline lens, or its capsule. The patient complains of gradually increasing dimness of sight; objects appear to be surrounded with a mist; and if we examine the eye when the pupil is dilated by belladonna, we observe an opaque body, of a grey, blue, or amber tint, behind the iris. Persons who have cataract see better in the evening, or when the pupil is dilated by belladonna. Opacity of the capsule occurs in spots or streaks, with less opaque intervals. Hard lenticular cataract usually occurs in old persons; it is small, and of an amber or grey colour. Soft cataract is more common in children; it is of large size, and of a bluish or pure white colour. Cataract may arise from inflammation consequent on a wound of the lens; in old persons it is generally the result of imperfect nutrition; it is sometimes a congenital malformation. Cataract can be cured by operation only. There are various modes of operating for cataract; extraction is the method which in this country is usually adopted in cases of hard cataract; it has the advantage of removing the disease at once; but on the other hand, it requires considerable skill for its performance, and is attended with the risk of some serious mishaps which the other operations are free from. In the operation for extraction an incision is made across the cornea with a triangular knife; the incision is made close to the margin of the cornea, and thus a flap is made of its inferior half, the aqueous humour escapes, a curette is introduced for the purpose of lacerating the capsule, then by slight pressure on the globe the lens is made to escape. Care must be taken that the vitreous humour does not escape with the lens. After the operation the eye must be bandaged, and the light must be carefully excluded for several days. The patient must be carefully watched, and inflammation is to be subdued by bleeding, leeching, and purging. The operation of depression is performed thus: a couching needle is passed through the outer side of the sclerotic, about two lines behind the margin of the cornea, and a little above the transverse diameter of the eye, so as to avoid the long ciliary artery. It is carried inwards in front of the cataract, and is steadily pressed upon it, so as to carry it downwards out of sight. The needle is then withdrawn. The method of reclination, which consists in turning the lens so as to make its upper margin project backwards into the vitreous humour is seldom performed.

The operation for producing absorption is easily performed, and excites little inflammation, but it requires repetition, and the cure is slow. It is best adapted for soft cataract. The needle is introduced in the same manner as for the last operation, or it may be passed through the cornea; it is then made to lacerate the capsule, and the lens being exposed to the action of the aqueous humour is gradually absorbed. After the operation for cataract the patient must make use of convex glasses to compensate for the loss of the lens.

*Glaucoma* is a disease which consists in a change in the structure of the hyaloid membrane and of the vitreous humour. It is marked by pain, gradually increasing dimness of vision, and a greenish discoloration

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Surgery. Diseases of the eye.

of the pupil. It is but little under the influence of remedies.

*Amaurosis* signifies an impairment of vision, depending on some change in the retina, optic nerve, or brain. At the commencement of the disease there is usually indistinct vision, objects sometimes appear doubled, or one-half only of an object looked at is seen; or objects may be disfigured or discoloured. Ocular spectra occur in the form of flashes of light, or floating spots, or a coloured network. The iris moves sluggishly, and in the advanced stages is totally motionless; in confirmed amaurosis the patient can distinguish no objects; he has a peculiar fixed vacant stare, and the eye-ball is protruded and motionless.

The causes of amaurosis are numerous and various. It may arise from inflammation of the retina, especially a slow inflammation induced by long-continued exertion of the eye, or exposure to a glaring light. Amaurosis may also be a consequence of organic change, inflammation, concussion, compression from extravasated blood, fractured bones, morbid effusions, tumors, or aneurisms, whether affecting the brain, optic nerves, or eye. Another class of cases are functional, and may result from loss of blood, long-continued lactation, or some other exhausting influence. Some cases appear to be sympathetic of distant irritation, especially of the gastro-intestinal canal. The treatment of amaurosis must be conducted with reference to the cause which has given rise to it. Inflammatory symptoms must be combated by bleeding and the cautious exhibition of mercury. If it can be traced to the action of debilitating circumstances, the administration of tonics, with the use of a generous diet, will be called for. If the amaurosis appear to be sympathetic of irritation in other parts, the source of irritation must, if possible, be removed.

Short sight (*Myopia*) may depend on some vice of original conformation, or it may be induced by the habit of looking closely at very minute objects. It depends on too great a refracting power of the media through which the light has to pass before reaching the retina. This may be obviated by the use of concave glasses.

Longsightedness (*Presbyopia*) depends on a diminished refracting power in the humours; it is one of the results of impaired nutrition consequent on old age. The only remedy is the use of convex glasses.

The eye is sometimes the seat of malignant disease, medullary fungus, or melanosis. These cases are almost invariably fatal; the disease returning even after the extirpation of the eye.

*Strabismus*, or squinting, consists in the non-correspondence of the optic axes of the eyes. The causes of this affection are various; it is not an unfrequent result of organic disease of the brain. In some cases we find it associated with opacity in the centre of the cornea. In children it is often produced by a habit of voluntarily turning both eyes towards the nose, in imitation of some squinting individual; the muscle which is thus frequently brought into strong voluntary action becomes more powerful than the other muscles, and the squint is rendered permanent. The most common form of strabismus is that in which one or both eyes are directed towards the nose; the outward squint is much less common, but it sometimes occurs in consequence of palsy of the third nerve. When squinting is the result of organic disease of the brain, or of opacity of the cornea, our efforts must be directed towards the removal of that condition of the brain or of the cornea. When it arises from an unnatural contraction of one muscle, or from a want of power in others, benefit is sometimes derived from covering the healthy eye with a bandage, and making the patient use the squinting eye so as to bring into play all its muscles. If this do not succeed, we may divide the tendon of the rectus muscle on that side towards which the eye is unnaturally drawn: the internal rectus is the one which generally requires division, and it may be done either with the scissors, by the help of a hook first passed under the tendon, or with a small curved sharp-pointed bistoury. After the division, the opposing muscle brings the eye into the proper position, the divided ends being separated to a certain extent, and in a short time becoming connected by new tissue, both to one another and to the globe. In some cases the deformity is entirely removed by this operation, but in others the squint returns to some extent, in which case the operation may be repeated on the opposite eye.

Before concluding our sketch it remains for us to say a few words of an important improvement introduced into the practice of surgery within a comparatively recent period—we allude to *lithotrity*. We have already spoken in brief terms of the operation of lithotrity, by which calculi formed in the urinary bladder by a slow deposition of salts from the urine, are extracted by an incision made into that cavity. The various attempts hitherto made to dissolve these concretions by chemical substances, either taken into the system through the stomach, or injected at once into the bladder by the natural outlet, have not been attended with the success which their advocates have anticipated, and although it would be premature to abandon all hopes of success from this mode of treatment, it is certain that the extraction of the stone is at present the only known remedy for this most painful and fatal malady. The operation of cutting, though not unattended with serious danger, yet as now practised by well-informed surgeons, is generally successful in uncomplicated cases, and it has the advantage of being a speedy and effectual cure where it succeeds. But on the other hand, it is an exceedingly painful proceeding, and one which, being accompanied by its peculiar risks of life, is greatly dreaded by patients, and consequently postponed in many instances beyond the period when it might have been performed with good chance of a favourable issue.

The operation of comminuting the stone in the bladder by means of an instrument passed along the urethra was first carried into effect by Civiale, in 1824; but the honour of devising the means appears to be shared by several, among whom may be mentioned the names of Amussat, Leroy, and Heurteloup, in particular. Our own countrymen, however, participated in the merit of having paved the way for the introduction of lithotrity. Various improvements have been since made in the instruments employed, by which greater strength as well as simplicity have been given to them. That now almost exclusively used in this country, and usually known by the name of its inventor, Mr. Weiss, consists of two blades, adapted to one another, and, when closed, resembling in shape the common short-curved sound. These blades slide one upon the other, and on being opened within the bladder may be made to seize the stone, upon which they are then closed. A screw force



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Surgery.
Lithotrity.

can now be brought to bear upon them, by which the stone is crushed. The jaws of the blades are armed with teeth to prevent the stone from slipping out, and the farther blade is perforated behind the position of the stone, to allow of the fragments falling out previous to the withdrawal of the instrument. For the performance of this operation the patient must be in good general health, the stone of moderate size, the bladder uninflamed and dilatable, the prostate gland unenlarged, and the urethra capacious. The patient is placed on his back, with the pelvis somewhat raised on pillows, to throw the stone towards the superior fundus. The urine is then withdrawn from the cavity and six or eight ounces of water injected to give room for the movements of the instruments, and to avoid risk of injury to the coats of the bladder. On the introduction of the *lithotrite* it is first used as a sound, to ascertain the position of the stone. It is then lowered on one side of the stone, which, on the blades being opened, generally drops between them without difficulty. They are then closed upon it, and carried into the middle of the cavity away from the walls, and the screw is then turned. The resulting fragments may be afterwards seized in a similar way, and further broken, until the whole is so much reduced as to be able to pass out by the natural channel. In the most favourable cases a few sittings are sufficient to accomplish this, and the patient is cured. It scarcely falls within our design to consider the various circumstances which interfere with this happy result, or which sometimes render it impossible of accomplishment. The reader who is desirous of particular information on this subject is referred to the last edition of the excellent treatise of Sir B. Brodie on urinary disorders, where he will find the best statement of the comparative value and several advantages of lithotomy and lithotrity hitherto published.

Surgery.
Operations for the cure of deformities.

We may also allude to the operations lately introduced with so much success for curing various deformities, depending on, or complicated with, contractions of muscles or their tendons. The different kinds of club-foot, contracted knees or fingers, and even certain curvatures of the spine, are now commonly treated by division of the shortened tendons. By running a narrow needle-like knife under the skin to the tendon, and dividing it alone, it is found that there is scarce any danger of inflammation; while a new fibrous structure becomes developed between the retracted ends, adding to the length of the tendon, and not weakening its cohesive power. To assist this operative procedure bandages and other apparatus are worn for some time, according to circumstances, and the operation may be repeated more than once if the occasion seem to demand. It will be observed, that the operation for the cure of squinting, already mentioned, is conducted on the above principle. We owe the principle to Stromeyer, who first publicly taught it in 1831; and its application to the treatment of strabismus to Dieffenbach, of Berlin.

We have now considered, more or less in detail, some of the more important subjects which come under the attention of the surgeon. The limits prescribed to us have made it necessary to select only such as appeared most adapted by their nature or importance to form part of a popular treatise: and we have been the more able to do this from the circumstance, that the article Medicine is intended to embrace the general history of disease, and thus to include much matter usually falling within the scope of works on Surgery. Enough, we trust, has been said to convey a just notion of the progress and present state of this useful and beneficent art, and to show how much may be expected, from its future improvement, in aid of suffering humanity.

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# INDEX TO THE SURGERY.





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# VETERINARY ART.

Veterinary Art.

Equine Pathology, under which term we comprehend a knowledge of the diseases to which the horse is liable, as well as of their proper treatment, is based on the same principles as those which regulate the art of healing in the human subject, and a surgeon may be said to possess three-fourths of the necessary knowledge required for the treatment of the diseases of this animal; the remaining one-fourth is, however, so important and essential, that without it his previous knowledge will not only be of little service, but calculated to lead him astray on some of the most important points, and produce dissatisfaction in his own mind, and death, or an increase of the disease, in the animal he may attend. It is essential to know the peculiarities in the structure and functions of various parts, the natural habits of the animal in all their minutiæ, and the peculiar action and effects of different medicaments, which a practical acquaintance with the animal alone can furnish.

History of the Art.

In the classic ages of Greece and Rome, veterinary medicine was regarded with attention, and thought worthy of the utmost consideration. Xenophon, the leader of armies, and Virgil, the prince of poets, did not disdain to write on the subject; and, even at the present day, with all the appliances of modern science, the precepts of these fathers of the art are not to be entirely discarded. With the downfal of the arts and sciences, veterinary surgery sank to the bottom of the pit of darkness, and was perhaps one of the last to approach the light of day. Worse than Egyptian was the darkness in which it was plunged through a long course of years. It was abandoned to the most ignorant of men, and got principally in the hands of those who were employed in shoeing horses, thence called farriers; and thus the treatment of the diseases of the horse was called farriery, which designation, though rather unmeaning, it has retained almost up to the present time. The knowledge of these rude professors consisted, for the most part, of some legendary lore, containing perhaps one truth with a dozen errors, and mixed up with the most absurd and cruel practices. Everything that was too barbarous and too *outré* for human medicine, even when it was at its lowest ebb, was enforced with the utmost rigour on the unresisting victim of man's ignorance and tyranny—the horse; and when kind nature had herself performed a cure in defiance of counteractive treatment, it was at once ascribed to the potent agency of some ridiculous compound. After human medicine had emerged from barbarism, and some most important discoveries had been made in physiological science, the aid which the dissection of animals had afforded in arriving at these discoveries induced some of its professors to turn their attention to the pathology of animals; and the horse, as being the noblest and most valuable of quadrupeds, received the most prominent attention. During the last century, several surgeons pursued as their vocation the treatment of the diseases of the horse, particularly in the metropolis of this country; and various treatises were written by them on the subject. These were considerably in advance of the practices of previous years; but being too closely in accordance with human medicine, various serious mistakes were made, both in the anatomical and physiological arrangement, as well as in the pathological treatment.

Veterinary College.

At length, towards the close of the century, a Veterinary College was established in London, chiefly through the instrumentality of an agricultural society at Odiham in Hampshire; and a Frenchman, of the name of St. Bel, who had studied at the veterinary schools in France, and had greatly assisted in forming the London College, was appointed its first professor. He entered with much zeal into his office, and produced a small work of some merit on the "Proportions of Eclipse." The London College, being supported by a great number of the nobility and wealthy gentry, who became subscribers, which entitled them to the privilege of having their horses treated gratuitously, may thus be said to be fairly established. St. Bel, however, did not long enjoy his new honours; he died about a year after his appointment to the office. With the establishment of the Veterinary College a new impetus was given to the science; a number of well-educated pupils became students; and, after the death of St. Bel, the professorship was held jointly by Mr. Morecroft and Mr. Coleman. The former, however, soon resigned, and for the space of nearly half a century the latter retained the office, making up in a great measure, by his talents and zeal, and medical knowledge, what, for some time, he lacked in practical ability. In this latter qualification, however, he was ably assisted by Mr. Sewell, one of the early pupils of the college, who became associated with him as a coadjutor, and succeeded, on the death of Mr. Coleman, in 1839, to the senior professorship, in which he continues, with the able assistance of Mr. Charles Spooner, Mr. Morton, and Mr. Simonds. Throughout the session, from November to May, lectures are delivered by these gentlemen in the various branches of their profession, the former taking up the anatomy, pathology, &c., of the horse; the second chemistry; and the latter the structure and diseases of cattle and sheep. Amongst the pupils who have studied at the College, some have distinguished themselves as authors, by whom, and others, the art has been greatly improved and advanced; diseases that were formerly thought nearly incurable now readily submit to scientific treatment; and a better system of management, which has been introduced through the medium of veterinary science, effects a considerable saving in the cost of horses in this country, and prevents many diseases whose ravages were formerly considerable. This change is more particularly noticeable in the army, where a veterinary surgeon is attached to each regiment, and holds the rank of a commissioned officer; and the value of his services are highly estimated.

A veterinary school has also been opened at Edin-



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burgh, by Mr. Dick, where pupils are instructed in the various branches of the profession.

Royal College of Veterinary Surgeons.

Though the Veterinary College has been under royal patronage for many years, the profession, which now consists of upwards of a thousand members, was not a chartered body till the last year (1843); but it is now duly incorporated as such, under the designation of the *Royal College of Veterinary Surgeons*, and possesses the power of framing by-laws and electing a council and president for the governance of the profession. It is therefore to be presumed, from these salutary measures, that the science of veterinary medicine will continue to advance, and will become, in consequence, of more practical utility to the public.

Composition of animal bodies.

Our object being to concentrate as much information as possible in a very limited compass, and to render this article as unique as possible, we commence with a brief outline of the various parts which compose the body of the horse. It consists of solids and fluids in different proportions, the weight of the latter being six or eight times that of the former. The organization of the frame is due to the solids which surround and contain the fluids. Animal bodies are composed of three forms of tissues, the *fibrous*, the *lamellar*, and the *globular*. The former characterizes the muscular and ligamentous tissues, and, united with the granular, is developed in the texture of the glands and in the medullary portion of the nervous system. Both the fibrous and the lamellar are exhibited in the composition of the cellular substance; and the globular is exemplified in the chyle, the blood, and several other secreted fluids. The combination, in different proportions, of these textures, form the various organs of which the body is composed.

The bones.

The *skeleton* of the horse consists of nearly two hundred bones, which are the most solid parts of the animal frame, to which they give support, and afford fixed objects for the attachment of the muscles and other parts. These bones are of various shapes and sizes, and are connected one to another by strong ligaments or bands, their ends being constructed in various ways so as to admit of motion, some resembling the structure of the hinge, and others that of the ball and socket. Bones owe their solidity to certain earths, the principal of which is the phosphate of lime, the other part of their structure consisting of gelatine and cartilage. When two bones meet together and form a joint, their ends are covered with cartilage, which again is lined by a delicate membrane which secretes the synovial fluid. This fluid prevents friction by lubricating the joint, and is prevented from escaping by the capsular ligament which is attached to the edges of each bone. When this cavity is opened, great pain, irritation, and fever are the consequence. The strength of the joints is still further secured by other ligaments, which run from one bone to another in different directions. The bones of the extremities are mostly long and cylindrical, and of great compactness and strength in the horse. The spinal column is formed by a great number of small bones of very irregular shape, having a hole through their centres for the spinal marrow and joint-like connections with the ribs: they are connected to each other by elastic cartilage, which permits the great flexibility which the spine possesses (though with greater strength) much less in the horse than in man or carnivorous animals. The head of the horse, consisting of about thirty separate bones, is of great size, the principal part of which is devoted to the face, enabling the animal to reach the ground readily, and affording ample space and a secure holding for the particularly large teeth with which the horse is furnished. This space is afforded without increased weight, by the face forming several large cavities. There are six *molar* teeth on each side of each jaw possessed by the full-grown horse, three of which replace the three temporary ones which the colt alone possessed, and the other three gradually appear as the jaws lengthen and enlarge.

The teeth.

There are six *incisor* teeth in each jaw, and two *cuspidati*, or tushes, which however, are absent in the mare. The incisor teeth replace a similar number of colts', or temporary, teeth, which may be distinguished as being much smaller, shorter, and whiter than the permanent ones. The appearance and changes which these teeth, particularly those of the lower jaw, undergo, enable us to judge pretty accurately the age of the horse for some years.

Mode of judging the age.

A two-year old colt has six temporary incisor teeth in the lower jaw; before he reaches three years, the two central ones are replaced by permanent teeth; between three and four, the two next are similarly replaced, so that a four-year old mouth has two corner temporary teeth alone; these likewise are lost and replaced before the horse is five years old, at which age the mouth is said to be perfect, the tushes having also now appeared. The inner edges of the corner teeth are, however, lower than the outer at five years old. The substance of the teeth is bone, or rather ivory, whilst all the surface that is exposed is covered with a still harder material called enamel, which, after casing the outside, dips down on the crown or face of the tooth, forming a deep cavity, which becomes black from being filled and stained with the food. This cavity, or *mark*, as it is termed, serves as another guide to the age for several years longer; for the teeth, gradually wearing from attrition, take about three years to wear to the bottom of the cavity. Thus the mark in the centre teeth disappears at six years old, in the two next at seven, and in the corners at eight, when the horse is said to be aged. As fast as the teeth wear, or faster, they grow from the roots, and their shape alters, so that by the time the horse becomes fifteen, the oval crown becomes triangular; and, as he approaches twenty, the oval is reversed: the teeth likewise become longer, and spring from the jaws almost horizontally.

The muscles.

The flesh, though apparently a homogeneous mass, is readily separable into a number of distinct bodies of various forms and sizes, which are called *muscles*. These muscles, which are made up of numerous fibres, possess the power of contracting their length, and being attached to two fixed objects, such as bones, draw them together, and thus the motion of the limbs is effected. They are generally attached to these bones through the medium of tendon, a strong white substance, which possesses no power of contraction, but merely serves to communicate the contractile force to the object to be acted on. When the distance is great between the two objects of attachment, it is principally occupied by tendon, by which means strength is preserved, whilst unnecessary size is avoided: thus it is that the legs of horses below the knee are small from the substitution of tendinous instead of muscular substance. Muscles are for the most part voluntary, but some, as the diaphragm and heart, are independent of the will, and therefore involuntary. They are abundantly supplied with vessels,

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Veterinary Art.

such as arteries, for their nourishment and support, and veins for the return of the blood after this function has been performed. They are likewise extensively furnished with nerves, which communicate sensation as well as the mandates of the will. These nerves arise either from the brain or its continuation, the spinal chord, so that sensation is first sent from the extremities to the brain by the nerves, and then, quick as the lightning's flash, the will is conveyed from the brain by another class of nerves (though bound up with the others), commanding the muscles to move the limbs. The *Brain* is a soft pulpy substance contained within the cranium, and the spinal marrow, which somewhat resembles it in appearance, extends through a hole in the bones of the spinal column from the head to the tail. The body of the horse is divided into two principal cavities, the chest and the abdomen, which are separated from each other by a muscular partition, called the *diaphragm*. The *Chest* contains the heart and lungs, whose offices are to purify and distribute the blood by means of the respiration and the circulation, whilst the *abdomen* contains the stomach and bowels, in which the functions of digestion, &c., are carried on with the assistance of the liver and the pancreas, besides the kidneys and other supplementary parts.

The brain.

The chest.

Digestive organs.

Mastication is performed by the molar teeth, whose faces are broad, so as to grind corn and hay as in a mill. The tongue, which is a muscular organ attached at its roots to a singularly shaped bone called the os hyoides, which connects it with the larynx, serves both to gather the food and submit it to the action of the teeth, and when properly masticated carries the morsel into the pharynx or food-bag, a muscular cavity situated immediately above the larynx. The food having been well ground by the teeth, and lubricated with a proper quantity of saliva, which is secreted by several glands, the principal of which are the *parotid*, situated in the angle just below the root of the ear, is then conveyed from the pharynx into the stomach by means of the *œsophagus*, a long muscular tube, which takes its course down the neck, between the two first ribs, through the chest, and piercing the diaphragm, enters the stomach in the cavity of the abdomen. The food having entered the stomach, is submitted to the chemical action of a peculiar fluid, called the gastric juice, secreted by the lining membrane of this organ. This having been accomplished, the *chyme*, as the food is then called, is passed into the small intestines, and is there mixed with two fluids, one of a watery nature, resembling the saliva, secreted by the pancreas or sweet-bread, and the other a yellow bitter fluid, called the *bile*, which is formed by means of the liver, from which it is conveyed to the intestines by means of the hepatic duct.

The *Intestines* are fastened to the spine by means of a strong membrane, called the *mesentery*, which serves as the channel for the communication of the arteries, veins, nerves, and absorbent vessels to and from the intestines. The latter are called the *lacteals*, and open into the inner surface of the bowels, and there absorb the nutritious portion of the food, a milky fluid called the chyle, and convey it to a vessel running along the course of the spine, and emptying itself into a large vein just previous to its joining the heart. It is thus that the blood is continually supplied with nutritious elements to supply the waste which the system is continually undergoing. Although thus furnished with nutriment, the blood is black and impure, and requires to be purified before it is adapted for circulating through the system. It therefore enters the right side of the heart, and by the muscular contraction of this organ, is pumped into the lungs, and being divided and subdivided by a multitude of vessels, is exposed to the action of the atmospheric air drawn in by respiration, and by it undergoes a rapid and remarkable change, from a dark to a light colour. Being thereby divested from its impurities, it re-enters the heart by its left cavities and division, and from thence is sent by means of the arteries to all parts of the system, supplying every part with nourishment, and the means of maintaining the temperature of the body. It furnishes also the various glands, not only with their proper nourishment, but also with means for the secretion of their peculiar fluids. Each gland separates its peculiar fluids, and no other, although the same fountain is employed for each, viz., the blood. The *urine* is separated by the *kidneys* from the arterial blood, and is conveyed through long tubes, called the ureters, to the bladder, whence it is excreted from the body. The bile, however, is separated by the liver from the impure venous blood, although this organ is supplied with arterial blood for its own nourishment.

Veterinary Art.

The circulation of the blood.

The circulation is carried on by two sets of vessels, the *arteries* and the *veins*; the former conveying the purified blood to all parts of the body, and the latter returning the impure blood to the heart again. The arteries are much stouter than the veins, and possess considerable elasticity; they terminate in minute capillary vessels by which nutrition is carried on and the animal heat developed, and this being accomplished, and the blood rendered black, it enters the capillary veins, which coalescing, the blood is conveyed by the veins to the heart to be again purified. After death there is no blood found in the arteries, but only in the veins, owing to the contractile power of the former, which the latter do not possess; they likewise possess no pulsating power, being too far removed from the heart to be so affected by its action. There are several important membranous substances, whose offices are very important in the body; first, we have the *cellular membrane*, which is an elastic material, connecting together the various glands and vessels, and existing in the form of cells communicating with each other. It also frequently covers the muscles, and is then condensed and thickened, and possesses much strength. The *adipose* membrane is that which secretes the fat; it is found in various parts of the body, arranged in circumscribed bags, into which the fat is deposited in an oily state. The *mucous membrane* is that which lines all internal cavities and passages having an external opening; it thus continues from the mouth and nostrils, through the intestines to the anus, and also lines the urinary passages, secreting a mucous fluid for their lubrication and protection. Cavities having no external outlet, such as the chest and the abdomen, are lined with a *serous membrane* which secretes a watery vapour, enabling parts to glide on each other without injury. These membranes are of great importance, not only in an anatomical, but also in a pathological point of view, being very frequently the subjects of severe disease.

The membranes of the body.

The various organs and tissues which we have briefly noticed, are connected together in a manner at once the most beautiful and economical. The contents of the



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chest and the abdomen are so disposed, that while each organ has sufficient room for the discharge of its peculiar functions, there is yet no vacant space to be found. There is, to use a well-known axiom, "a place for everything, and everything in its place."

Disease.

DISEASE may be defined as a departure from health, or, as Liebig observes, it exists when the vital force is weaker than the chemical forces opposed to it, whilst death occurs when all resistance to these forces ceases. It may be either structural or functional, that is, it may be owing to an alteration of the structure of an organ or part, or merely a derangement of its functions: inflammation of a part, such as the foot or eye, is an instance of the former, whilst simple fever is an example of the latter. We may have both these states combined: for instance, a part may be in a state of inflammation; its structure may be thereby either temporarily or permanently altered, and at the same time fever being excited in the system, the heart may send the blood with double rapidity through the body, and be thus diseased in its functions, whilst its structure may continue unchanged.

Fever.

*Simple fever* is an example of diseased function, though it often produces local inflammation. It is, however, very rare in the horse, as an independent disease, there being generally some local affection when fever is present in the system, and when it does occur, local inflammation more rapidly supervenes than in the human subject. Though less subject to fever, however, the horse may be considered as more liable to—

Inflammation.

*Inflammation.*—The symptoms which usually attend an inflamed part, though all of them are not present, in every case, are swelling, redness, pain, and heat. The swelling is in the first instance owing to the distended state of the vessels of the part; but afterwards effusion from the surfaces of these vessels takes place: the redness is to be attributed to the greater quantity of blood contained in the vessels, and often to the presence of the red particles of the blood in minute vessels, which in a state of health are too small for their admission. The pain is produced by the pressure of the enlarged vessels on the nerves of sensation: this symptom, however, is not so invariably present as the others, and depends partly on the amount of the swelling, and partly on the sensitiveness of the affected organ. Heat is an invariable symptom, and is owing to the development of a more than ordinary quantity of caloric (the principle of heat), from the presence of an unusual portion of arterial blood. An inflamed part, therefore, is more abundantly supplied with blood than when in a state of health; and if the inflammation continue, the blood-vessels become enlarged, and sometimes new ones are formed; permanent enlargement of a part takes place. We have frequent instances of this in the horse, as, for instance, in the thickened state of the flexor tendons of the legs, which often remains after inflammation has subsided.

Inflammation is subject to much variety, depending on the nature, and situation, and importance of the organ, and the degree of severity in which it may exist. It may attack an unimportant part, and produce no constitutional derangement, or it may affect the brain, the bowels, or the lungs, and excite in the system symptomatic fever to a most formidable extent. In the former instance, the inflammation is usually called local, its effects being confined to a particular part; though strictly speaking, inflammation is always local, the symptomatic fever which often attends, being owing to the irritation diffused through the system by means of the nerves, and acting on the heart so as to cause its increased action. Thus local inflammation often produces fever in the system, and on the other hand, general fever sometimes produces local inflammation.

Inflammation may be either acute, sub-acute, or chronic. The former is inflammation in its most active state, an *actual* flame, and is frequently, though not always, attended with symptomatic fever: the second is inflammation of a mild or subdued character, a sort of smouldering fire, and is less frequently attended with constitutional irritation: the third denotes a long-continued and settled inflammation, the smouldering embers of the conflagration which the first kind had established.

Inflammation, although a disease, is yet but the result of the too active existence of a process which is most essential to the system, and without which wounds would not heal, or the loss of parts be restored. It may be excited by various causes: bruises, strains, and injuries may produce it externally; and internally it may be occasioned *directly* by the actual contact of an irritating object, such as a drastic purgative or poisonous substance; or by the too great action of a particular part, as the lungs in over-exertion, or otherwise indirectly, as when catarrh is produced by the application of cold to the skin. Inflammation is much governed and directed by the idiosyncrasy, or peculiar susceptibility of the animal. It is rare that every organ is formed equally strong: in some the lungs is the weakest, and in others the liver may be the most vulnerable; and thus the same cause will produce different attacks in different animals. This, too, is much influenced by the season of the year, and the age of the animal: diseases of the abdominal organs are more frequent in the summer, and those of the air-passages in the winter; and young horses are more susceptible to the latter, and old animals to the former.

*Plethora*, or a redundancy of blood in the system, is not unfrequently the cause of inflammation, though not so frequently as in cattle and sheep, from the circumstance of the horse being in some measure relieved by active exercise. When every vessel of the body is loaded with blood of the richest and most stimulating character, we cannot be surprised that inflammation of the most susceptible organ, or that most exposed to disease, should arise. In human pathology inflammation is spoken of as being either *phlegmonous* or *erysipelatous*; in the horse it is nearly always of the former character, and very seldom of the latter. The eruptive affection of the skin called *erythema*, being almost a singular instance. Plethora.

The results of inflammation under disease are simply those carried to excess which occur in a state of health, and are necessary and natural processes for the repair of the effects of an injury. When the inflammation gradually subsides, without any of the other effects, a result which in disease we are always desirous of accomplishing, it is termed *resolution*. When the fibrine or adhesive portion of the blood is deposited, it is termed *adhesion*; this is often the result of inflammation of a *serous* membrane, such as in pleurisy, and it is likewise exemplified in the healing of a wound by the first intention. *Suppuration* is the termination of inflammation, to which mucous membranes are most Effects of inflammation.

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disposed, and it is best illustrated by the formation of pus or matter in an abscess. Adipose tissue is more disposed to suppuration, and the cellular membrane to adhesion. *Ulceration* is the absorption or removal of substance, a sequel of inflammation, also illustrated by an abscess, and which always takes place before it bursts, the substance between the matter and the skin being gradually removed at some particular part, where the abscess is said to point. It may occur, however, either with or without suppuration, and it may be either in a healthy or an unhealthy state. In the former, the ulcer, as a running sore is called, soon heals, and in the latter, it will gradually spread and increase. It sometimes attacks the cavity of a joint, and then it is very rarely attended with suppuration, but usually with adhesion.

*Mortification* or gangrene, as the death of a part is called, is a less frequent termination of inflammation in the horse than in the human being. Bone and cartilage, and parts whose circulation are inactive, are most liable to this process. A bone when much injured often becomes carious, a portion becomes dead, and exfoliates, as casting-off is termed.

Before we can speak of the pulse as the best indicator of inflammatory action, or of those remedies which we find most available, it will be essential to notice the peculiar properties of the blood, and the phenomena which obtain with regard to it.

**The blood.** The *Blood* is not only the most abundant, but also the most important fluid in the animal economy. It furnishes every part of the body with nutriment for its growth, and affords the material from which the various fluids are secreted, and influences considerably the strength and disposition of the animal. Formerly its derangement was considered as the sole cause of disease, whence the term humoral pathology; but this theory has in great measure given place to another, in which the solids are considered the principal agents, and seats, of disease. We find, however, that there is some truth in both these doctrines: the solids are subject to morbid affections; and that the blood is occasionally both altered in its composition and impaired in its quality has been satisfactorily proved by late research, and is, for example, the primary cause of the symptoms of fever.

**Composition of the blood.** Three-fourths of the blood is composed of water, which is essential in order to preserve it in a liquid state, and enable it to flow freely through the intricate labyrinths and minute and circuitous channels which nature ordains it to take. The other elements have each their distinct office to perform, and the whole is essential to preserve it whilst in the vessels of the body in an apparently homogeneous state. When, however, it is removed from the body, it soon separates into different portions. After some hours we observe a division between the solid and fluid parts; the former floats in the latter, and is called the *crassamentum*, whilst the liquid is termed the *serum*. The serum is composed principally of albumen and water, which can be separated by the application of heat, and the crassamentum chiefly consists of fibrine and the colouring substance or red globules, with which are mixed various salts. These parts may be separated by washing; and they also appear when the blood is long in coagulating; the red portion, being the heaviest, falls to the bottom, whilst the fibrine remains at the top, constituting what is usually termed the buffy coat of inflammation. These particles of the blood do not nourish, but convey oxygen, for the purpose of heat. The blood, it is well known, is considerably darker in the veins than in the arteries, being in the latter of a bright scarlet, and in the former of a dark purple hue. The red tinge of arterial blood is considered to be owing to the presence of various salts, and the dark colour of venous blood to that of carbon, which is prevented from rendering it quite black by the salts. The blood becomes, by means of respiration in the lungs, in great measure freed from "carbonaceous principles," which being removed, it acquires, through the salts, its scarlet colour. The air, by being respired, loses a great portion of its oxygen, and acquires carbonic acid gas in its place. This gas is produced by the chemical combination of the carbon of the blood with the oxygen of the atmosphere; but the greater portion of the lost oxygen is absorbed by the blood, enters into the circulation, and conveying with it a considerable quantity of caloric in a latent form, is the medium by which the body is supplied with animal heat: this caloric becoming sensible in the capillary vessels, obedient to a law of chemistry, that when carbon is formed heat is elicited. Thus in cold countries a greater quantity of animal heat is required than in hot climates; to supply which more oxygen is inhaled, more nutritious food consumed, and more carbon extricated. It should be observed, that the lungs are greatly assisted in the removal of carbon from the blood by means of the liver, which for this purpose is largely furnished with venous blood. Thus when one of these organs is diseased and unable to perform its functions, the other likewise becomes deranged, having a double duty to perform. The blood, although composed of various substances, which readily separate when removed from the body, yet appears as a simple fluid whilst circulating in it. It has been discovered by the aid of the microscope to contain an immense number of small globular bodies, computed to be about 3·500th part of an inch in diameter. The globules of the blood are suspended in the serum by means of the vital influence derived by the blood from the vessels and organs through which it passes; which also is supposed to give them a rotatory motion and a mutual repulsion towards each other, whereby they are kept asunder. As the blood, however, enters the capillary arteries, its globules are attracted and appropriated as required for the purpose of nutrition. The blood is thus preserved by its vitality from coagulating or disuniting whilst circulating; but when removed from the body, and thus deprived of vitality, it both coagulates and separates; and thus coagulation is longer or shorter in taking place in proportion to the vitality possessed. Thus, when the animal is weak and low, it quickly congeals; and when full of vigour and excitement, it often takes a quarter of an hour to do so, and gives full time for the fibrine and the red particles (which have no longer any vital influence to keep them together) to disunite and follow the influence of gravity.

**Changes of the blood effected by respiration.**

We have alluded to the vital influence which the blood derives from its vessels. These vessels or arteries are abundantly furnished with a peculiar class of nerves, developed by modern science, which have nothing to do with conveying sensation or the motive will, but are devoted to the superintendence of organic life. They arise neither from the brain nor spinal chord, but from various knots or ganglions, which receive numerous

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branches from other nerves, thus keeping up an intimate communication between all parts of the nervous system. The heart is controlled by nervous influence in a still greater degree; it holds direct and powerful communication with the brain, and it is influenced with the speed of lightning by most of its sensations, and is instantaneously affected by mental emotion. If we approach a nervous horse we well know how greatly the pulse is increased, and it is sometimes several minutes before it is reduced to its natural standard.

The pulse. The *Pulse* is felt in any part of the body in which an artery approaches sufficiently near the surface to be felt. It appears like a jerking action of the artery; but if we lay bare the vessel, as in the nerve operation, we cannot perceive any of the action, although it may be felt by slightly compressing the vessel. It is therefore principally owing to the powerful muscular contraction of the heart, which thus sends the blood with greater force and by successive jerks into and through the arteries; so that if we slightly compress the latter, the impetus is felt constituting the pulse. The circulation of the blood is, however, supposed to be assisted by the elastic and muscular coats of the arteries. The pulse, our principal and best indicator of disease, may be felt either at the heart or the arteries; the beating of the former, however, slightly precedes the latter, though not perceptible to common observation. In health the degree of strength, as well as quickness, corresponds both in the one and the other; but sometimes in disease the artery can scarcely be felt, whilst the heart at the same time beats hard and with apparent force against the side. It is, therefore, often necessary to examine the pulse both at the side and at the jaw. The different varieties of force, &c., &c., with which the heart beats has been characterized by various terms, such as hard, soft, full, small, intermittent, irregular, quick, slow, &c.; but sometimes these distinctions have been in equine pathology carried further than practical examination will warrant or justify.

Variations in the pulse. The *average pulse* of a horse may be considered to be about 35 in a minute; in some we find it as low as 26, in others as high as 42: under disease it as often greatly increased, sometimes indeed much exceeding a hundred. An increased state of the pulse is in itself an evidence of much derangement of the system, unless it be merely owing to exertion or temporary excitement. It shows that the blood is hurrying through its vessels much quicker than it ought. A *quick pulse* may be produced by exertion and mental excitement, as before observed; or it may be owing to pain, local inflammation of a part, or disordered state of the blood as in fever. Though pain is not an unfrequent cause, yet it does not invariably produce a quick pulse; but when it does so it is by irritating the nervous system, and then the pulse is not only quick but strong, as in the case of an open joint, and the blood seems to possess an increased vitality. Local inflammation is one of the most frequent causes of quick pulse in the horse, and its agency in producing it depends very much on the importance and magnitude of the organ so inflamed. The eye or the foot may, for instance, be affected without producing an increased pulse; but the lungs, the brain, or the kidneys, are never acutely inflamed without exciting greatly the action of the heart. Inflammation is an increased action of the capillaries of a part—more blood is contained by such part; but this is not all, for more blood may be possessed when the part is *congested*, the distinction being that the former is an active and the latter a passive state of the vessels. It is thus essential either that a local inflammation should occasion pain, or that it should cause an interruption to the flow of blood or other fluid, or at any rate that it should be of a certain magnitude and importance, in order to produce a quick pulse. A *quick hard pulse* is often termed an inflammatory pulse, but such term is by no means appropriate, for we may have this so-called inflammatory pulse without inflammation, and inflammation without an inflammatory pulse. Such pulse does not in many instances so much depend on the local inflammation present as on the condition and the idiosyncrasy of the animal. Another variety of quick pulse is that found in fever and influenza: it is usually soft, and when greatly accelerated, small and weak; there is an increased quickness of the heart's action, but a decreased power; and though the system is disturbed, there is often no local inflammation present of any consequence. Such pulse is usually attended with an incapability of bearing much depletion, and a rather dark state of the blood, which soon coagulates and never has a buffy coat.

We rarely find an unnaturally *slow pulse* in the horse, but when present it often denotes some affection of the liver, or it may be owing to sluggishness or debility of the system, though debility is oftener attended with a quick weak pulse. A *full strong pulse* generally denotes an abundance of the circulating fluid, and a capability of bearing blood-letting, if required. If quick as well as strong, it betokens excitement of the system, and perhaps local inflammation. We usually find such pulse in acute rheumatism or chill, as it is commonly termed, and sometimes in chronic rheumatism. It also accompanies most diseases attended with much pain, and is found in cases of open joint: it denotes great irritation of the organic nerves. A *soft pulse*, if not quickened, betokens a state of health, though sometimes a too great langnor of the system. A *hard pulse* generally attends inflammation; it may accompany a full pulse or not. A wiry pulse is one of its varieties, being small and hard, feeling indeed much like a wire. A *small weak pulse* denotes a low state of the vital functions, and is generally attended with dark blood, and forbids blood-letting to much extent. It accompanies the absence of nervous energy, and the want of excitement, and is often present when the body is cold. In the early stages of inflammation it bespeaks an incapability of bearing much depletion; and in the latter stage, an exhaustion of the nervous energy and the vital powers. When it attends inflammation, it is always very quick.

An *intermittent* pulse is sometimes met with in an apparently healthy horse, though it is somewhat doubtful whether there may not be some latent disease present. When it follows a quick pulse in inflammation, and particularly after the exhibition of digitalis, it is a favourable type, and appears to be a method of nature for lowering the heart's action. An intermittent pulse may be either regular or irregular; the former is much more favourable than the latter. Indeed, an irregular vacillating pulse, whether intermittent or not, is a very unsatisfactory sign, and often appears as the precursor of death. The nature of the pulse requires these observations, for it is one of the best and surest guides in the treatment of disease, and particularly in the practice of blood-letting.

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**Blood-letting.**

Amongst the remedies for inflammation, the most prominent, and in the horse decidedly the most important, is *blood-letting*; and it is most essential to know when to practise it, and when to abstain. The history of blood-letting in the human subject is almost coeval with the practice of physic, and in animals its antiquity is almost as great. In the former its effects were found so considerable when first introduced, that it became very generally adopted, and indeed far more extensively than at present, for the now widely extended *materia medica* furnishes the scientific practitioner with numerous medicaments that enable him to dispense with bleeding in many diseases in which it was formerly practised. Till very recently it has been the practice to carry bleeding to a great extent in the horse, to adopt it on each and every occasion; and even at the present time it is the custom of farriers to resort to it in every case, no matter what the symptoms may be, satisfying their consciences by the ignorant *placatio*—that if it does not do good, it can do no harm.

**Mode of performing the operation.**

Bleeding is performed either with a lancet or a phleme; the former is the more difficult, and requires a skilful hand, and a sharp point to the instrument. The right side of the neck is the most convenient situation. The head being elevated so as to put the vein on the stretch, the latter should be pressed with the fingers of the left hand, and the skin and vein opened with the same incision, about six or eight inches below the angle of the jaw. In using the phleme, the left side is the most convenient; the instrument being held in the left hand which presses the vein at the same time, it should be struck smartly on the back either with the side of the right hand, or an instrument called a blood-stick. In bleeding from the arm or the thigh, the phleme is the most suitable instrument.*

**Effects of bleeding.**

In a case of simple plethora, the first gush of blood appears of a dark colour, which is owing to its detention in the vein, by pressing with the finger in order to make it swell or rise. As the operation proceeds, the blood becomes lighter, and this is in proportion to the rapidity of the current, which, if very great, as it often is, if the horse will eat hay or grass at the time, the blood is of a red or arterial hue. After several quarts have been removed, the blood generally becomes darker, and does not flow so rapidly, and the pulse, at first strong and full, becomes softer, less full, and sometimes quicker; and if the bleeding is carried to a considerable extent, almost or quite imperceptible, the horse hangs his head, shifts his weight from one foot to another, and exhibits other symptoms approaching to *syncope*, though it is very rare that actual fainting is produced. During the operation, the membrane of the nostril and the eyelids gradually change from a red to a pale colour; and the mouth, at first hot, becomes by degrees cool. Some little time after the bleeding, the pulse is increased in quickness, though still comparatively weak, which may be in great measure attributed to re action. The immediate effect of bleeding then is to diminish the supply of blood to the right side of the heart: that organ has less to send to the lungs—a smaller quantity is reddened and purified—less oxygen is absorbed from the atmosphere, and a diminished quantity of purified blood is conveyed to the left side of the heart, and thence through the system. The supply of arterial blood being diminished, the small vessels become less distended, and thus the various membranes are rendered pale, and there being less blood supplied, there is less caloric given off, and thus the mouth and other parts become cooler. The stomach quickly sympathizes with the general depression, and a sense of nausea and loss of appetite is induced. The brain and nervous system are very early affected by the loss of blood, occasioning a want of energy, weakness and depression of spirits, and it is probably in great measure through the nervous system that the sedative effect on the heart is produced. The quantity of blood in the vessels, though temporarily reduced, is very soon restored by means of absorption of watery fluid, that would otherwise have passed off by other channels, but the blood is rendered considerably weaker; the fibrine and the red globules that have been removed are by no means restored—this can only be done by means of the chyle, and in the course of time. When the loss of blood by bleeding is rapid and considerable, the pulse can scarcely be felt; and if depletion is carried further, the brain is deprived of its supply, and thus fainting is produced, which may take place earlier or later, according to the rapidity of the current, and the ability of the animal for losing blood: it is therefore very important that the blood should flow as rapidly as possible and from a large orifice.

If the blood has previously been too stimulating, abounding too much with fibrine and albumen, and thereby exciting too much the heart and blood-vessels, we obtain relief by rendering the blood poorer by venesection; but if the blood was previously poor, we produce by bleeding a state of debility difficult to overcome. Another effect produced by bleeding, and perhaps more important than any yet considered, is the powerful sedative influence it has upon the heart and arteries. This it is that we seek to obtain in cases of inflammation: when an important viscus is actively inflamed, and the heart is pumping the blood with double rapidity and force through the frame, and keeping up general irritation and local inflammation, by abstracting a large quantity of blood, we depress the action of the heart, and cause a less quantity of blood to be sent to the inflamed part, in common with other parts of the body: we do so not only by diminishing the quantity of blood, but still more by lessening the force with which this quantity is sent, thereby giving the part time to relieve itself from its superabundance of blood. Thus by the loss of blood three important effects are produced in the animal economy—a diminution in the quantity of the blood, an alteration in its quality, and a sedative effect on the heart and arteries.

**Cases in which blood-letting is required.**

A plethoric state of the system requires bleeding, and particularly in the spring of the year: when the horse has been highly fed, and little worked, full of flesh, and heavy, and sluggish in consequence, the abstraction of a few quarts of blood will be useful, and perhaps prevent inflammation of some part. It should not, however, be carried to a great extent. If a

* After bleeding, a swelling sometimes takes place round the part, from the escape of blood under the skin. This *thrombus* generally disappears, either without treatment or by means of cold applications. Inflammation of the vein, however, sometimes follows; the swelling, if in the neck, extends upwards, feels hard; the passage of the vein is obliterated, suppuration occasionally appears with sinuses, and sometimes hæmorrhage. The head should be tied up for a week; soft food only should be given, fomentations and cold lotions employed topically, and succeeded by repeated blisters. If there is bleeding, a styptic or caustic may be applied to the wound, but by no means injected into it.

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greater reduction is required by the system than this will produce, a dose of physic should be given which will lessen the quantity of blood, by the removal of some of its serum, and it will in some measure diminish the supply of chyle. The plan of periodical bleeding is to be deprecated, for the desired effect can be obtained by abstinence and physic.

Inflammatory diseases in the horse are more frequent than in the human subject, and blood-letting is demanded in the greater number of them. It is not, however, sufficient merely to ascertain that inflammation exists in order to practise bleeding, particularly to a large extent; for inflammation may exist, and yet the pulse be so feeble that bleeding will be injurious, and perhaps fatal, and be the means of throwing away what chances we possess of saving the animal. It is still less sufficient to determine on bleeding merely because the pulse is quick; for this state may exist without any inflammation, and without requiring or benefiting by the operation. If in an inflammatory case we have reason to expect a superabundance of fibrine in the blood, then bleeding will be demanded, and to a free extent. We may anticipate this state of the blood when we find a strong, full, and quick pulse; and we shall then perceive the blood a long time coagulating, and presenting afterwards a thick buffy coat: we may ascertain this even while the blood is flowing, by touching its upper surface in the vessel with the finger, on which it will leave no stain. The proportionate quantity of buff is much greater at first, and gradually diminishes, which may be ascertained by receiving a little in different glasses at the commencement, the middle, and the end of the operation. It is also much greater if the orifice is large, and if it is caught in a narrow vessel. the influence of gravity causing the heavier red particles more readily and abundantly to separate. The extent of the bleeding must be regulated not only by the appearance of the blood, the readiness of its flow, and the strength of the pulse, but also by the severity of the inflammation and the importance of the organ affected. If, for instance, the above symptoms exist in a case of acute inflammation of the lungs, we can scarcely take too much or take it too rapidly. We should, if possible, knock down the disease by the first blow; and we shall generally succeed in so doing, for the appearance in such severe cases of buffy blood not only shows the propriety of blood-letting, but also the capability for bearing it. The pulse in this, as in almost every instance, should guide us as to the quantity to take: the bleeding should be continued until it becomes almost, if not quite, imperceptible. In all cases of rheumatic inflammation—and these cases are by no means so rare as is generally supposed—and in almost all instances of inflammation of a fibrous part, such as the cavity of a joint, the fibres of a muscle, and also in most cases where acute pain is present, we shall find a full, strong, and quick pulse. Indeed, this is the true pulse of irritation, and not a quick weak pulse, as used to be supposed.

Let us take, for example, a horse with a bad open joint, there is great irritation of the whole system, and the pulse is strong, full, and accelerated. The horse is bled, and we find a buffy coat on the blood: the joint is not closed—the irritation continues; the pulse soon acquires its former character; the animal is again bled, and the buffy coat is again exhibited. This may be repeated again and again; the poor animal loses flesh, is almost a skeleton, can scarcely stand, and at length dies; but almost to the last he exhibits a strong pulse and buffy blood. We well know that nothing produces so rapid a loss of flesh as acute pain. In such case the whole nervous system is in a state of irritation; the organic nerves which supply the blood-vessels equally participate, and the blood-vessels are irritated, if not inflamed. The fibrine of the blood, instead of being attracted by the coats of the capillaries, and thus contributing to the growth of the body, is hurried forwards into the veins, and thus the venous blood becomes loaded with fibrine, whilst the solids are almost exhausted from its absence, and of course the animal is considerably and rapidly impoverished. Although a single bleeding or two may be useful in such case, yet it is clearly evident that its frequent repetition will fail both in altering materially the character of the pulse, as well as the appearance of the blood. Both the blood and the pulse can often be restored to a state of health by other means, either by medicine, or, as in the case of an open joint by closing the cavity, and removing the cause of irritation.

Sometimes a strong full pulse, and its usual concomitant buffy blood is principally owing to the idiosyncrasy of the animal, which may possess such pulse, but which may be increased by the irritation of disease, contrary perhaps to the usual character of such disease. Thus when influenza has been prevalent, perhaps in one case out of twenty, instead of the usual soft pulse there has been a hard strong pulse and buffy blood, contrary to the usual indications of the disease; therefore, though as a general rule inflammatory cases require blood-letting, there are exceptions that should always be borne in mind.

Cases forbidding blood-letting.

Let us suppose that a horse is overrun in the chase —is exhausted and can scarcely stand—his flanks heave laboriously, and if a vein is opened, the blood is black and flows with difficulty, and the lungs are congested with black blood: should we bleed in such a case? When an animal is exhausted with exertion, the blood becomes much darker than usual, and the flesh decomposes more rapidly than otherwise. When the circulation is thus hurried by exertion, the demand for arterial blood in every part is so great that the lungs cannot purify it with sufficient rapidity, and consequently it is imperfectly done; and this imperfection increases until, loaded with carbon, it is no longer fit for the purposes of life: impure blood is sent to the brain, and the animal dies. It would at first sight seem that the removal of some portion of this dark impure diseased blood must be desirable and calculated to relieve the loaded lungs; but let us look a little further: the powers of life are greatly reduced, the system is exhausted, and the vitality of the blood and its vessels are considerably impaired; by removing, then, any portion of blood, impure as it is, we subtract from the system the vitality which it possessed, and reduce still further the nervous energy, and thus hasten a speedier dissolution. The exhausted system requires assistance; the waning powers of vitality need support; the nervous system demands a stimulant. An ounce of laudanum and two of spirits of nitrous ether, with a pint or less of water, or a pint or more of brandy and water of the usual strength, or a bottle of port wine, will often restore the vital powers, and enable the system to contend effectually against the approach of death; and as the pulse becomes perceptible, and the dark colour of the blood changed, blood-letting may be

Treatment of over-exertion.

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practised if required, with safety and success. In all cases in which the pulse is low and feeble, the treatment should commence with a diffusible stimulant; and bleeding should not be practised until the stimulant has strengthened the pulse and re-action has commenced. If we bleed in the latter stages of inflammation, within perhaps 12 or 24 hours of death, we assuredly hasten the period of dissolution, and perhaps produce almost sudden death, although we only remove a few quarts of this dark impure blood, which appears so unfit for the purposes of life. The repetition of bleeding is often resorted to empirically, and without principle. It is not uncommon in severe inflammation, if the horse appears no better in the course of 6 or 12 hours, to bleed, and again a third or a fourth time for the same reason, regardless alike of the actual state of the case or the ability of the horse for bearing depletion. By such practice a fatal termination is not only greatly precipitated, but what chance there may be of recovery is altogether thrown away. The propriety of repeating the bleeding should be regulated by the principles we have endeavoured to establish: it should be practised with caution and with the finger on the pulse.

Local bleeding.

Local bleeding is a practice to which we are very favourably inclined. We can seldom abstract blood from the inflamed part itself, but as near to it as possible, taking care that if we open a vein, it shall be between the heart and the seat of inflammation. We can rarely resort to local bleeding in the horse for severe internal inflammations, the thickness of the skin and the presence of the hair precluding the application of both leeches and the cupping-glass; and we are compelled to limit our practice almost entirely to the opening a vein or an artery. From the size of our patients, and their consequently large veins, we can open them in various situations with convenience and good effect. For severe *strains* of the flexor tendons we may open the brachial or the saphena veins with much advantage, and remove a large quantity of blood. For *Laminitis* we may bleed from the foot, opening the circular artery and abstracting blood in a large and copious stream. For various diseases of the foot, or near it, we may also bleed from the toe or the coronet, placing the foot afterwards in a pail of warm water to encourage the bleeding. For inflammation of the gums we can bleed from the mouth: for ophthalmia or injuries of the eye we can abstract blood locally, by scarifying the lids, lancing the bars of the mouth, and opening the angular facial vein, or the jugular. Each spot has its peculiar advantage, and deserves a preference in particular circumstances. One important rule should be observed in local bleeding in severe cases, such as acute strains; that is, to abstract blood enough locally to affect the system generally; by so doing we gain the advantage of both local and general bleeding. If we do not carry it to this extent, and the pulse is strong, the little blood we abstract locally will soon be supplied by the system almost as plentifully as before; therefore, if we cannot obtain in such case sufficient blood, it will be desirable to bleed generally at the same time.

Re-action.

There is another point that deserves particular attention, and that is, the tendency of bleeding to produce a re-action. We bleed for internal inflammation, and appear by so doing to subdue it altogether, but in the course of 12 or 24 hours perhaps it rages as strong as ever. The disease, it is said, is returned; but no! it is re-action, as Dr. Copland well shows, and produced sometimes by the excess of bleeding. How desirable then is it to guard against this re-action; and for this reason after bleeding, we employ sedatives, our belladonna, our digitalis, or white hellebore, and by their means prevent the fire in a great measure from again flaming forth; and this, we take it, is the chief use of these medicaments.

When the blood abounds with fibrine, as in many inflammatory and rheumatic diseases, we may assist the bleeding and prevent perhaps the necessity of a second operation, by administering medicines calculated to attenuate the blood, such as tartarized antimony, calomel, cream of tartar, digitalis, the carbonates and salts, with plenty of diluents. When the blood is very dark, there appears to be a deficiency of its saline constituents, and we shall then probably find much advantage in employing the chlorides, and fixed alkaline salts.

When the clot is very loose and coagulates rapidly, indicating considerable debility of the system, tonics, vegetable and mineral, camphor, and the alkalis, are called for. When the blood is very deficient of fibrine, acids are found the best restorative of this constituent, and prevent attenuation of the blood. In dysentery and profuse diarrhœa, where the watery portion of the blood is considerably diminished, diluent liquids should be given, with astringents, mild tonics, and saline matters.

It should not be forgotten that blood-letting greatly promotes absorption. In cases, therefore, of inoculation with morbid matter, the bites of venomous reptiles, a local disease that may become constitutional, abscess, and unhealthy ulcers—in such cases bleeding should be carefully avoided.

Purging.

*Purging*, as an agent in the treatment of inflammation, is not so available in the horse as in the human subject, in consequence of the greater danger that attends the operation, and more particularly in inflammatory affections of the air passages. In these cases the utmost caution is required, for numbers of horses have been destroyed by the injudicious administration of physic. For local inflammations of the limbs and other parts, purgatives are still in requisition, and are also generally employed in getting a horse into condition. The *modus operandi* of a purge is by stimulating the internal coat of the bowels, and causing a greater flow of blood to it, and consequently a greater secretion of the watery fluids; it excites also the muscular coat, and causes a greater peristaltic action of the intestines, by which means their contents are rapidly hurried onwards and discharged. Its immediate effects on the system are—firstly, the depression it causes in the nervous system, and thereby on the action of the heart and arteries, giving time for an inflamed part to recover its natural tone during the existence of this depression; and secondly, the removal of a portion of the circulating fluid from the body. It is by this latter effect that a horse is got into condition; he comes up perhaps from grass loaded with flesh and fat, but is unable to perform active work, and sweats readily from the slightest exertions. Nothing assists so much in altering this state of things as a dose of physic; the superfluous serum and fat is removed from the system, and exercise being added, the horse becomes lighter and stronger, in better wind, and fitter for the performance of exertion. The best purge that can be given to a horse is Barbadoes aloes; an ordinary dose is from five to six drachms melted in a water bath, and mixed with one drachm of ginger and two drachms of

A purgative ball.



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treacle. Although this may be considered as a medium dose for a full-sized horse, yet some are purged with three drachms, and others require upwards of an ounce, depending on the strength of constitution and the susceptibility of the intestines. Light heron-gutted horses are much easier purged than animals with a good carcase. Before administering a dose of physic, it is desirable to know exactly the quantity the animal requires to act properly on him; and if this knowledge cannot be obtained, it is better to give under than over the amount he may appear to require. From the length and extent of surface of the intestines, a dose of physic, if given in a solid form, as it usually is, takes about twenty-four hours before it begins to purge; it is therefore better to give it in the morning, the animal having had for one or two days previously bran mashes, no corn and but little hay. When a horse is well mashed, a less dose of physic is required; it will also act better, and with less danger or inconvenience. After the physic has been administered, the mashes should be given warm, and lukewarm water to drink *ad libitum*. The following morning the horse should have walking exercise; but if the motions are soft and frequent, he should be put in the stable again; and if the physic does not act, the animal may be trotted. So that in fact we can control the operation of the physic by the amount of exercise: care, however, being taken that it is not too severe, and that the animal does not take cold, as from the weakness and depression of the nervous system there is a chilliness and a greater susceptibility to the influence of cold air. The warm bran mashes should be continued during the action of the physic. A little corn may be given in the evening; and on the second day after the administration of the ball the horse should remain quietly in the stable, having, however, his usual food; and he should not be worked till the next day, and then very moderately. When it is desirable to administer another dose, an interval of a week should elapse between the first and second ball.

Treatment of the horse in physic.

Laxatives.

When merely a relaxed state of the bowels is required, and this in many diseases is the safer course, a half dose of physic or laxative may be given, so as to produce a pultaceous state of the fæces without active purging.

Diuretics.

*Diuresis* is the increased action of the kidneys, from more blood being determined to these glands, causing more urine to be secreted by them. It thus acts in somewhat the same manner as a purgative, by diverting blood from an inflamed part and getting rid of superfluous water in the system; but it can be employed with greater safety, and is, therefore, more available in internal inflammations; and is particularly useful in dropsical swellings of the legs. The following is a useful formula:—

| | |
|---|---|
| Powdered yellow resin . . . . | 4 drs. |
| Nitrate of potash . . . . . | 2 „ |
| Powdered ginger . . . . . | 1 dr. |

To be beat up with sufficient soft soap to form a ball. A diuretic acts much more quickly than a purge; it should therefore be given early in the evening, and its effects will have passed off in a great measure by the morning. The horse will not imperatively require any alteration in the diet or cessation from his usual work.

Sedatives.

*Sedative medicines* are often administered in inflammations; their effect is to lower the action of the heart and arteries, and this is accomplished in various ways; some, such as the *white hellebore*, in doses of a scruple, or small quantities of aloes, produce nausea in the stomach, and this depresses the nervous system in the same manner as emetics act in the human subject. From the peculiar conformation of the stomach, and curvature of the œsophagus as it reaches it, the horse is unable to vomit, though he may feel sickness or nausea. *Digitalis* or *foxglove*, in doses of half a drachm to a drachm, appears to act specifically on the heart, lowering its action, and producing, temporarily, an intermittent pulse. Belladonna, or the deadly nightshade, seems to act directly on the nervous system, the action of which it lowers. About two drachms of the extract of belladonna is an ordinary dose. Opium is also a valuable sedative, in doses of a drachm, and, combined with the protochloride of mercury, in a similar dose, its assistance is often very valuable.

Sudorifics.

*Sudorifics*, as a remedy for inflammation, are much less available than in the human subject. We cannot, as in man, throw a horse into a profuse perspiration; and a warm-water or vapour bath, from the size of the animal and his hairy covering, is a very inconvenient remedy. When, however, the skin feels chilly, and we wish to determine blood to the surface, we may produce this effect by giving a drachm of camphor and one or two ounces of spirit of nitrous ether, suspended in gruel, or with water thickened with linseed meal so as to suspend the camphor, which will not dissolve in water.

Fomentations.

In the treatment of local inflammation, in addition to the foregoing remedies, which act on the system at large, as well as local bleeding, which has also been noticed, we have several other resources. *Warm fomentations* act by relieving the inflamed vessels by means of perspiration or the escape of fluid externally through the pores of the skin. In applying them, a thick flannel should be used, not too wet, but kept closely to the part for some time. *Warm poultices* act in the same manner, but, of course, produce a more constant effect.

Lotions.

*Cold applications* relieve inflammation by means of *evaporation*; heat is thereby abstracted from the inflamed part, and the action of its vessels is lowered with its temperature.

Counter-irritation.

*Counter-irritation* is another method of removing inflammation; it is most available after other treatment, and when the disease becomes sub-acute. It acts by exciting artificial inflammation in another part, and thereby diverting the blood from the old mischief. Blisters, setons, and rowels are the principal remedies of this class employed in the horse.

Having gone at some length into the general principles by which the diseases of the horse are to be combated and overcome, we shall now proceed to notice these diseases *seriatim*; but our limited space will only permit us to adopt the most concise method, and point out the principal symptoms that belong to each malady, without attempting to detail the almost endless variety in the order as well as the severity with which these symptoms appear. We select, in the first place, the *diseases of the chest* and air-passages, as being some of the most frequent and important, first, however, making a few observations on the structure of the parts. The passage for the air to and from the lungs is effected by a long tube, called the *trachea* or *windpipe*, composed of a great number of cartilaginous rings, connected together by strong elastic membrane. Thus constituted,

The windpipe.

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The larynx. the channel is preserved in whatever position the neck may be placed. The upper part of this tube is called the *larynx*, and is formed of various singularly shaped cartilages, guarded by a valve, called the epiglottis, which is always open except in the act of swallowing. These cartilages are moved by numerous small muscles, and are connected by them with the *pharynx*, or food-bag immediately above, so that the entrance to the stomach and that to the lungs, though distinctly separate, are yet situated close together, and are often involved in the same disease. The horse breathes only through his nostrils, which are wide and capacious for the purpose; and there is a fleshy membrane, called the *velum palati*, which, attached to the palate-bone above, falls down on the dorsum of the tongue, and closing the back of the mouth, is only raised in the act of swallowing. In man and carnivorous animals this soft palate is shorter, and does not prevent breathing through the mouth. All these parts, in common with the mouth and the nostrils, are very liable to disease, and are lined with a mucous membrane, which, at the larynx, is endowed with a high degree of sensibility by means of several nerves.

Catarrh. CATARRH, or *cold*, as it is usually termed, consists of inflammation of the mucous membrane just spoken of: that lining the nostrils is generally first affected, and thus sneezing is one of the earliest symptoms. Cough and sore throat follow, with fever, either slight or more severe. Catarrh may either be very slight or very severe, but it is usually more serious than in the human subject: very frequently it becomes epizootic, and attacks many animals at the same time. In the first stage, the discharge from the nostrils is watery, but sometimes there is none at all; it afterwards becomes thick mucus, which is sometimes very considerable, and gradually ceases as the animal gets better.

*Treatment.*—Bleed moderately, unless the symptoms are very slight or the horse very weak; rub some blistering liniment on the throat and between the jaws.

*Liquid Blister.*

| | |
|---|---|
| Cantharides, powdered | 3 drs. |
| Hartshorn | 4 oz. |
| In a fortnight strain and add | |
| Olive oil | 4 oz. |

Keep the body warm and the stable cool; give bran mashes, carrots, or green food, and a little walking exercise daily, unless a loose box can be afforded. If the bowels are anywise costive, give two or three drachms of aloes, and the following cough-ball daily:—

*Cough Ball.*

| | |
|---|---|
| Digitalis | ½ dr. |
| Camphor, powdered | 1 ,, |
| Tartarized antimony | 1 ,, |
| Nitrate of potash | 3 drs. |
| Linseed meal | 1 dr. |

To be made into a ball with Barbadoes tar.

Repeat the blister if necessary, and, in severe cases, insert a seton under the throat, and steam the nostrils by means of a hot mash and a nose-bag. In epidemic cases the treatment should be pretty nearly the same as above advised; but, as there is generally greater debility present, the depletive measures must be practised with caution, and it will often be advisable to give a few tonic or condition-balls after the inflammatory symptoms are removed.

*Tonic Condition-ball.*

| | |
|---|---|
| Powdered ginger | 1 dr. |
| ,, gentian | 2 drs. |
| ,, camphor | 1 dr. |
| ,, sulphate of iron | 2 drs. |

To be made into a ball with linseed meal.

Strangles. STRANGLES is a disease to which most young horses are liable, between the ages of two and five. The symptoms are, in addition to those of catarrh, a phlegmonous swelling under the jaws, which generally terminates in an abscess, and which it is essential to open as soon as it points. This disease is generally more severe in horses that have been in work some time before it appears, but it is usually followed by an improvement of the health and spirits.

*Treatment.*—We should avoid bleeding if possible, but in other respects adopt the same treatment as in catarrh, repeating the blister several times. When the glandular swellings remain hard and do not suppurate, it is called, in horseman's phraseology, bastard strangles, and the ointment of iodide of mercury should be repeatedly rubbed into the part.

| | |
|---|---|
| Iodide of mercury | 1 dr. |
| Lard | 1 oz. |

To be well incorporated.

Sometimes there is a disposition to form abscesses in various parts of the body, and the disease proves tedious and troublesome; and if abscesses form internally, death is occasionally the result. Shivering fits are often present, and the symptoms are very deceptive. Tonics are here demanded. Catarrh unsubdued often brings on—

Bronchitis. BRONCHITIS, which is inflammation of the air-passages of the lungs. This disease may arise from extension of the inflammation along the course of the mucous membrane, or it may be the primary disease; for it should be observed that the windpipe, on reaching the chest, divides and subdivides into numerous ramifications, which terminate in minute air-cells. These air-passages are cartilaginous in their structure, and lined with the same mucous membrane as the throat and windpipe. Bronchitis is a severe and dangerous disease, and its symptoms are often very deceptive. We have most of the symptoms of catarrh, but the cough is weaker, the pulse is increased in frequency, and the respiration somewhat disturbed; the appetite is considerably impaired, and the membrane lining the eyelids and nostrils inflamed. The discharge from the nostrils is copious, and white, or sometimes yellow; the legs are usually of their natural temperature; and the horse does not refuse to lie down, although he prefers a standing posture. If the case gets worse, the pulse becomes quicker and weaker; the breathing short, quick, and catching; the discharge from the nostrils somewhat offensive, and occasionally of a dark colour, or streaked with blood. Sometimes this disease is so severe from the first that the membrane lining the air-passage becomes of a dark red, and afterwards of a green colour, and the dsicharge is entirely suppressed: all the symptoms are of the worst character, and death marks the animal as its own from the very onset of the disease; and afterwards the membrane of the air-passages is found of a deep green colour.

*Treatment.*—Avoid aloes or other purgatives as we would poison. If the bowels are really costive, give care-



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fully half a pint to a pint of linseed oil; bleed according to the state of the pulse and the principles we have laid down under the head of blood-letting; repeat the bleeding once or twice in twelve or twenty-four hours, but venesection must not be too copious; blister the throat and the brisket, and sometimes the sides, and insert setons in the chest; steam the head; keep the body warm and the stable cool; bandage the legs; give the fever-ball twice a-day for several days, and when convalescent, the condition-ball a few times.

Structure of the lungs.

PNEUMONIA, or inflammation of the substance of the lungs, is not a rare disease in the horse. The *lungs* are composed of the air-tubes and cells we have spoken of, and a vast number of veins and arteries, both large and small, the whole being connected together by cellular membrane called *parenchyma*, and covered externally by a serous membrane, which also lines every other part of the chest. These light spongy bodies are divided into several lobes, and fill accurately every part of the chest not occupied by other organs, expanding and contracting with that of the thorax. They float readily when placed in water, and are but a few pounds in weight, and of a pale pink colour. Their office is, as we have seen, to admit simultaneously a large quantity of air and of blood, and by exposing them to each other, separated only by a very thin membrane, a mutual change and exchange takes place in both the air and the blood; the latter acquires oxygen, loses carbonic acid gas, and becomes red; the former loses oxygen, acquires carbonic acid gas, watery vapour, and becomes warmer and lighter.

The horse being an animal whose utility is owing, to a great extent, to his capability of performing great exertions, and thereby calling largely on the lungs for the extra performance of their natural functions, we cannot be surprised that these organs, so often unduly exerted, should be liable to derangement and disease.

Congestion of the lungs.

We notice two varieties of inflamed lungs: one which can scarcely be so called, as it is rather *congestion* than inflammation, arises from over-exertion, or a plethoric state of the system. When it becomes fatal, the lungs are found quite black, from every vessel being loaded and distended with impure blood, thus producing suffocation. The *symptoms* can scarcely be mistaken: the breathing is rapid and distressed in the extreme; the pulse very rapid, small, and weak; the limbs cold; the appetite lost; and the membrane of the nostrils very highly injected; and it is often fatal in twenty-four hours, or less.

*Treatment.*—Give a diffusible stimulant, hand-rub and bandage the legs, and as soon as the pulse becomes stronger and more perceptible, bleed with the finger on the pulse. Employ counter-irritation and febrifuge medicine. We sometimes meet with cases in which, with the most rapid and distressed respiration, the pulse is strong and hard, as well as rapid. In such instances we shall be able to employ with advantage very copious venesection; six or seven quarts of blood will not be too much to abstract. These cases seem to border between that we have described and the true—

Pneumonia.

PNEUMONIA, which may be produced by over-exertion, or the heated body being suddenly or too quickly cooled, producing re-action, or exposure to cold; or, still more frequently, by a stable too hot and confined. It may also follow the congestive pneumonia previously spoken of.

The *symptoms* sometimes are very obscure, leaving it somewhat doubtful whether the lungs are really affected, and which can only be positively ascertained by means of *auscultation*, or applying the ear to the chest. In these obscure cases the inflammation is usually confined to a portion of the lungs; the ear will detect the absence of the usual respiratory murmur in the affected part, which thus gradually becomes condensed and impervious to the passage of air. This disease is frequently preceded or attended at its commencement by a cough, which, however, does not increase, but rather diminishes. The appetite becomes impaired, the animal appears out of sorts, and, if the pulse is examined, it will be found somewhat accelerated, and the respiration perhaps doubled, and attended with a sort of catch. In this stage it may be considered as *sub-acute*, and so it may continue until relieved by treatment; but more frequently in a few days it assumes a new form, in which the appetite is nearly or totally gone, the respiration treble or quadruple that of health, being from thirty to sixty in a minute, the pulse from sixty to ninety, and sometimes full and distinct, at others small and weak, presenting in different cases very different characteristics. The legs feel cold, the mouth hot and clammy, and its secretions often offensive. If the animal gets worse, these symptoms are all increased, the pulse becomes quicker and weaker, and the respiration rivalling it in rapidity; and thus the disease may go on, occasionally perhaps presenting slight gleams of hope which prove delusive, and in the course of five or six days terminates fatally. The *post mortem* appearances are those of *hepatization* or condensation of the greater portion of the lungs, which is impervious to the air, and sinks in water. White lines and knots are often found, and sometimes tubercles and abscesses. In cases where death supervenes in a very few days, and there is yet considerable hepatization, it denotes previous disease, either of a chronic or acute character. In some instances we find the lungs in a state approaching to gangrene, the smell very offensive, and the parts still pervious, full of a brown sanious fluid: some portion of the lungs is usually black, like that in the previous disease, which part is generally that last attacked, for this congestion or black state of the lungs, instead of denoting long standing disease, as used to be supposed by farriers, actually proves the contrary.

*Treatment.*—Bleeding is certainly the sheet-anchor; and for the principles by which it should be regulated we must refer to the article on Blood-letting, contenting ourselves with observing here that it should be as copious as possible, the first bleeding particularly. If the pulse is at the outset weak or small, we cannot do better than administer two ounces of spirit of nitrous ether in half a pint of water, or, if the bowels are costive, half a pint to a pint of linseed oil; and if this should have been delayed till after the bleeding, and the blood should appear of a dark colour, it may then be given with advantage. We may afterwards resort to sedative and febrifuge medicine, administering a ball two or three times a-day. White hellebore, digitalis, extract of belladonna, calomel in combination with opium, have all been recommended and employed. They have each their peculiar advantages, which must govern their selection. The former, perhaps, is one of the most powerful, but requires very careful watching, so as not to push it too far.

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*Sedative Ball.*

| | |
|---|---|
| White hellebore, powdered | ½ dr. |
| Or extract of belladonna | 2 drs. |
| Or digitalis | 1 dr. |
| Or calomel 1 dr. with opium | ½ dr. |
| Nitrate of potash | 2 drs. |
| Tartarized antimony | 1 dr. |
| Linseed meal | 2 drs. |

Treacle to form a ball, and one to be given twice a-day.

Counter-irritation is an important addition to our treatment, and the blister is most useful, as producing the most speedy effect. In a very severe case it is difficult to get a blister to act properly, but it is more likely to produce a proper effect on the brisket than on the sides. Setons and rowels may be also conjoined, and, in subacute cases, preferred as producing a more lasting effect; and they will be found particularly useful if the case has become chronic. If we have reason to fear that hepatization has commenced in the lungs, it will be advisable to employ the preparations of iodine both externally and internally; half a scruple of the iodide of potassium may be added to the sedative or other ball, and the ointment of iodide of mercury may be employed externally. When the inflammatory action appears pretty well subdued, and much debility remains, it will be advisable to administer a few tonics, the best combination for which will be the sulphate of iron, ginger, and gentian, a drachm and half of each, made into a ball with treacle, and given once or twice a-day.

Pleurisy. PLEURISY or PLEURITIS, which is inflammation of the pleura or lining membrane of the chest and lungs, used to be considered as never occurring but in connection with pneumonia. More accurate and extended observation, however, has satisfactorily shown that, although not so frequent as the latter, and though often combined with it, it yet does occur in many instances as a pure disease. Though many of the symptoms resemble those of pneumonia, it may be readily distinguished from it by the much stronger and harder pulse, the occasional exhibition of acute pain, causing the horse to paw and even lie down, and the tenderness evinced on pressing the sides. The inflammatory type is more strongly marked, but there is much less external coldness and less debility. The breathing is less difficult, but painful and variable; the inspiration is quick, but the expiration slow; the membrane of the nostrils is not injected as in pneumonia, and the symptoms altogether are more changeable. The appearances after death (which, when the case is fatal, often takes place in seven or eight days, unless the disease becomes chronic) are those of extensive derangement of the membrane affected, which is often in a gangrenous state, portions of the lungs adhere to the chest, and flakes of lymph are thrown out. Sometimes there is no deposition of fluid, but more frequently there is a considerable quantity secreted, amounting to many gallons, in one or both cavities. When there is much water, the other diseased appearances are less considerable, as this *hydrothorax*, as it is called, is the result of the inflammation, and the effect of the expenditure of its force. When water is forming, the symptoms are moderated, purging sometimes comes on, and on applying the ear to the chest, the usual respiratory murmur cannot be heard, but sometimes on moving the horse, the gurgling of the water can be detected, and the chest, when gently struck, gives out a dead sound.

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The *Treatment* must be somewhat similar to pneumonia—bleeding must be employed, if possible, to a still greater extent, and it will be found that there is a greater ability for bearing it. It must be repeated if required. Counter-irritants and sedatives should also be employed. Scruple doses of opium will be a useful addition to the sedative ball, and the other treatment must resemble that which we have advised for pneumonia. If hydrothorax is strongly suspected, or proved to exist, we should abstain from further bleeding, as this is calculated to encourage the watery secretion. Tonics should then be given with diuretics, such as sulphate of copper one to two drachms, with ginger and gentian, in similar quantities, made into a ball with Venice turpentine. If the water appears to exist to a large amount, the operation of *paracentesis*, or tapping, should be employed. The trochar being plunged into the chest, between the eighth and ninth ribs, as low down as possible, the water will escape through the canula, which is left in the wound till all is evacuated. The operation should be performed on both sides, unless it is evident that the water is confined to one cavity, and generally requires to be repeated. Its success will depend very much on the amount of disease that may exist independent of the water on the chest; for when confined to the deposition of serum, it is much more likely to be successful.

*Pleuro-pneumonia* is the complication of inflammation of the lungs with that of the pleura, and though not so common as the former, it is more so than the latter disease. The symptoms are more obscure than either, though partaking of the character of both, and the result is still more frequently fatal. The *Treatment* must be in great measure similar to that we have advised, regulated, however, by the peculiar symptoms, and the predominance of those of the one disease or the other. Pleuro-pneumonia

The HEART is rarely the subject of inflammation, and fortunate is it that it is not so, for as it is the organ which is called upon for increased exertion in all cases of fever or inflammation, were it much disposed to inflammation itself, the more serious diseases would then be far more dangerous than they really are. Diseases of the heart.

CARDITIS, as inflammation of the heart is termed, is always connected with other disease, and seems to arise from the undue exertion of the organ. When the heart is affected, it increases the danger of any other coexisting disease. Carditis.

PERICARDITIS, or inflammation of the heart-bag, is much more common; it often accompanies pleurisy, and occasionally pneumonia, and sometimes rheumatism; it nearly always terminates in the deposition of water and lymph in the pericardium (*hydrops pericardii*) which by pressing on the heart oppresses it considerably, and at length chokes its action. The presence of water in the heart-bag considerably modifies the other symptoms, and renders the pulse weak, vacillating, and sometimes intermittent. It is very important to detect the existence of pericarditis when it occurs in conjunction with pleurisy or pneumonia, as the same amount of blood-letting cannot be borne, nor is it advantageous. Pericarditis. Hydrops pericardii.

HYPERTROPHY, or enlargement of the sides of the heart, occasionally exists either with or without dilatation of its cavities. Sometimes there is simply an increase Hypertrophy.

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of its muscular parietes, at others an enormous growth of a cancerous structure, which may chiefly appear on the exterior, or, as in a case which has occurred in the writer's practice whilst writing the present article, in one of the cavities. In the case referred to, that of a thorough-bred filly, a fungous substance actually occupied three-fourths of the right ventricle, and after occasioning some constitutional derangement for some time, at length produced sudden death. The disease is usually accompanied by a peculiar pulse, quick, full, and strong, but with a laboured action; the carotid arteries may often be seen to beat as they rise from the chest; the heart palpitates, and is often irregular and intermittent in its action. The disease, though frequently fatal, is best treated by moderate bleeding and sedatives, of which apium is the best; and if the horse apparently recovers, his work should be very moderate.

Cancer of the heart.

Rupture of the heart.

*Rupture* of the heart sometimes, though rarely, occurs. In most affections of the heart, the appearances are very deceitful; there being no pain of any amount or threatened suffocation, the appetite is often but little impaired, and the respiration by no means hurried. Thus, though there is a somewhat haggard appearance of the horse, the attendants are disposed to disregard it, or ascribe it to temporary causes, and the animal is often not considered to be ill until he is actually at the brink of death.

Spasm of the diaphragm.

*Spasm of the Diaphragm* has often been mistaken for disease of the heart: a loud thumping noise has been heard, which appears to come from the heart; but it is found that it can be heard and felt at other and different parts of the body, and the noise does not synchronize with the pulse, being less frequent; it appears on examination to correspond with the breathing, and to be owing to the violent spasmodic action of the diaphragm. It is generally produced by over-exertion, and particularly if taken on a full stomach. The treatment should consist in administering an ounce of tincture of opium, and two ounces of spirit of nitrous ether, in a pint of warm water. After which it will be proper to bleed more or less severely, according to the strength of the pulse. If the bowels are costive, oily laxatives should be given with injections. The antispasmodic may be repeated in a few hours. This treatment will generally prove successful.

Rupture of the diaphragm.

*Rupture of the Diaphragm* now and then occurs: it is produced by excessive exertion or coughing, and is attended by great distress, rapid and very peculiar respiration, and is invariably fatal in a few hours, or in several days, according to the extent of the rupture.

Besides the diseases of the respiratory organs which we have noticed, there are several others which, though not fatal in the result, are yet so serious in their nature as greatly to interfere with the utility of the animal, and considerably impair his value. The first we shall notice is Broken Wind, as it is popularly and expressively designated. The symptoms of this disease are a peculiar and well-marked breathing, which is not only quick, but attended with a prolonged expiration, and a double action of the abdominal muscles. The appearances of the lungs of broken-winded horses sufficiently explain this peculiar respiration, for we find that they are much larger than usual, but without increased weight; the size being occasioned by air, which has escaped from the air-cells, and become infiltrated under the membrane. The disease then consists of a rupture of the air-cells, and though the air can be drawn in with ease, yet there is a difficulty in expelling it, as might be expected, and thus the double expiratory effort. Broken-winded horses are of course incapable of performing the same amount of exertion as before, but their ability depends on the amount of the injury, and the mode and nature of the feeding. The lungs being to a certain extent at all times inflated with air, much of which is in a situation where it cannot be usefully employed, it is evident that the horse must breathe quicker than usual, in order to inhale in a given time the requisite amount of atmospheric air, which distending still more the inflated lungs is with much difficulty expelled, and requires a double and long-continued effort to accomplish it. When the case is very bad, the horse rarely appears in good condition, and there is often much external coldness manifested: the latter symptom may arise from a less quantity of oxygen, one of the sources of heat, being absorbed, and the former from the indigestion which is generally present, and which also occasions the great flatulency that is often exhibited. A peculiar short dry cough is usually present, which is greatly increased if the horse eats foul or dusty food. There is generally an unusual dryness, and sometimes a thickening of the membrane that lines the air-passages, and which appears to be the immediate cause of the cough. Though broken wind is not curable—though it is impossible to restore the ruptured air-cells—yet very much can be done in the way of treatment, and this must principally consist in avoiding all dusty and unwholesome provender, and giving the horse nutritious food in a small compass, in order that the stomach may never be overloaded so as to press too much on the chest. It is more particularly essential that the horse should not work on a full stomach. Green food may be given in the summer, and carrots in the winter; but he should not be turned out to grass or straw-yard, but kept in as high condition as possible. Broken wind usually comes on gradually, but it sometimes occurs suddenly; and the writer has several times been requested to attend cases supposed to be inflamed lungs, but which he found was broken wind, unexpectedly produced: sudden and severe exertion, on a full stomach, was in each case the exciting cause.

Broken wind.

Thick wind.

Thick Wind, though frequently confounded with, is yet very different from, that just described. The respiration is greatly increased, but without the distress of pneumonia, or the double action of broken wind. It is occasioned by a partially impervious state of the air-passages, which may be caused either by the condensation of the lungs from pneumonia, or a thickening of the parieties from chronic or sub-acute inflammation, which may have been mistaken for a common cold, and passed unheeded. The space for the air being thus limited in extent, more frequent respiration is necessary, and which is more particularly the case after and during exertion. It is often, though not always, attended with a cough; but there is not such dryness of the membranes as in broken wind. The same mode of management should be adopted as in the former disease.

Chronic cough

Chronic Cough is closely connected with the two diseases last described; it often accompanies, and frequently precedes them, but it may occur altogether unaccompanied by any impairment of the wind. In such instances it is the effect of catarrh and sore throat, and such horses are more subject to take cold than others,

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and then the cough becomes increased. In many cases it is impossible to decide merely from hearing it that the cough is chronic; but the horse, when it is not very bad, usually coughs several times on first being trotted in the morning, and sometimes it does not return throughout the day. It appears to arise from a thickening of the mucous membrane of the larynx or other air-passage, and a consequently altered state of its secretions, which become thicker and more viscid. The advice we have given as to the previous diseases is in most respects applicable to this; but we may in addition derive some benefit from stimulating the throat externally, and administering occasionally a cough ball. It is very requisite to adopt the most active measures whenever a horse with chronic cough becomes affected with catarrh or sore throat, in order to prevent further alteration of structure.

Roaring.

Roaring is another disease of the larynx of frequent occurrence, and of serious import, affecting the most valuable horses, and often reducing their value 80 or 90 per cent. It derives its appellation from the peculiarity of the noise made in breathing, this noise being occasioned by the air rushing through a contracted channel. Anything, therefore, which diminishes the natural calibre of the larynx or wind-pipe may occasion roaring; and thus we find it proceeds from a variety of causes, such as a contraction of the wind-pipe itself, bands thrown across it, thickening of the membrane of the larynx, ossification of its cartilages, absorption or attenuation of the muscles which open the larynx, and distortion of both wind-pipe and larynx, or either. The noise is not heard when the horse is at rest, or at moderate work, but only when the respiration is increased by exertion. There is of course a great variety in the degrees of roaring; some horses make a noise as soon as they are trotted, others not until they are put to the top of their speed. This depends to a great extent on the amount of impediment that may exist, and partly on the condition and capability of the horse for performing fast exertion. Thus the same degree of obstruction that would make a heavy horse roar in the trot, will perhaps only occasion the noise in a thorough-bred horse during a gallop. Different degrees of obstruction occasion variations in the sound produced; and thus we have the names, whistlers, wheezers, and high-blowers, given by horse-dealers to horses that roar. Independent of the nuisance occasioned by the disagreeable noise, there is an incapability of performing the same exertion as before, in consequence of the obstruction preventing a sufficient quantity of air from entering the lungs in a given time, and sometimes suffocation is produced in consequence.

*Treatment.*—As a general rule we may state that there is no cure for roaring. It is only when there is actual sore throat, or inflammatory action going on in the larynx, or morbid changes very recently formed, that we can afford relief; but in such instances we often can do so, to a considerable extent, by the continued application of iodine combinations externally at the region of the larynx, assisted by the administration of hydriodate of potash internally, at first perhaps combined with calomel, and afterwards with vegetable and mineral tonics. The horse should be kept in the highest condition, and not allowed to overload his stomach previous to exertion. It is customary sometimes to place a strap, so as to press on the nostrils, which diminishes the noise in bad roaring. This, however, does not enable the horse to perform more labour, but it merely lessens the noise by preventing the admission of more air than can readily pass through the contracted larynx. In the greater number of cases there is neither cough nor imperfection of the wind attending roaring; when the former exists, it denotes that the roaring proceeds from the morbid deposition produced by sore throat, &c., or laryngitis.

Abdominal viscera.

Diseases of the Abdominal Viscera.—It will be convenient to preface this part of our subject by a few observations on the comparative structure of the organs, of the diseases of which we intend to speak. Compared with man and carnivorous animals, the *abdomen* of the horse is of large volume, though for evident reasons comparatively smaller than that of the ox or sheep. The nature of his food requires considerable size in the intestines, and these of course demand a corresponding cavity for their reception; and thus we find that horses with very small bellies, though willing and free, are incapable of long-continued exertions, and carry very little flesh in their work.

The abdomen is lined by a dense, strong, and elastic cellular membrane, called the *peritoneum*, which is also reflected on the viscera, and secretes a watery vapour or fluid, which lubricates every part, and enables the almost continual motions of the bowels to be executed without injury. The lower part of the abdomen is occupied by the large intestines when the horse is in a standing posture, and the small guts are above them.

The stomach.

The *Stomach* of the horse is very small compared with most other animals, and usually contains about three gallons; it is however a strong muscular cavity, capable of considerable distention: it is situated on the left side, and when full, presses on the diaphragm, and mechanically impedes its action. On cutting into the stomach, we find that one half is lined by a white cuticular and almost insensible coat, and the other half by a red villous and very sensitive membrane, which secretes the gastric juice by which digestion is in a great measure effected. It has two openings,—one in the cuticular coat, called the cardiac orifice, which receives the food from the œsophagus, and the other in the villous coat, called the pyloric orifice, through which the food passes into the intestines.

The intestines

The *Intestines* of the horse are very spacious and of great length, being no less than ninety feet, the greater part of which length is formed of the small intestines. They are composed of three coats, the peritoneal, which we have spoken of; the muscular, by which its snake-like movements are effected, and the mucous, which secretes a mucous fluid for its protection. The small intestines contain about eleven gallons, and the large eighteen: the chyle is principally absorbed in the former, by the small vessels called lacteals, whose mouths open on the inner coat of the intestines.

The bowels are fastened to the spine by a strong membrane, called the *mesentery*, which serves as the medium of communication of the numerous vessels and nerves which pass to and from them. The inner surface of the intestines is of vast extent, exceeding that of the surface of the body: the large intestines are puckered by strong bands, which serve to give support and at the same time increases the interior surface. The small intestines are called the *Duodenum*, the *Jejunum*, and the *Ileum*; but the distinction is quite arbitrary. The large ones are, however, with greater reason dis-

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Veterinary Art. tinguished as the *Colon*, the *Cœcum*, and the *Rectum*; the former is the largest, containing no less than twelve gallons; the second is the chief receptacle for fluids, and has a blind extremity which first appears on opening the abdomen; the last is the smallest and most posterior, from which the fæces are expelled by its strong muscular coat.

The liver. The *Liver*, the largest gland in the body, is of a reddish-brown colour, and irregular figure, being divided into lobes. It is fastened to the diaphragm, and kept in its situation towards the right side by strong portions of peritoneom. It is supplied with arterial blood for its own nourishment, but it separates the *bile* from impure venous blood, with which it is furnished by some large veins. The bile. The bile thus formed passes into the intestines at once, there being no gall-bladder in the horse, through the hepatic duct. The quantity secreted by the horse is relatively much greater than in man, being no less than 37 lbs. in the course of 24 hours. We are indebted to Professor Liebig for some new and important ideas with regard to the use of the bile. It used to be supposed that its office was confined to the digestion of the food, and that it stimulated the intestines to the performance of their functions; but it appears that its principal use is to separate the carbon of the transformed tissues from the venous blood, and convey it to the bowels, where the greater portion is again absorbed and taken into the system; it thus furnishes carbon for uniting with the oxygen of the atmosphere, by which union the heat of the body is supplied and maintained. The bile contains 90 per cent. of water, the remainder consists for the most part of carbon, besides which there is soda, which also re-appears in the blood, and finally escapes from the system with the urine. Thus it is that diseases of the liver generally occur in hot weather, when the system is loaded with carbon, for then, there being less demand for heat in the body, there is less oxygen inspired, less carbon excreted by the lungs, and more conveyed and re-conveyed to the liver; and thus in inflammation of the liver the blood is often loaded with fat and oil.

The pancreas. The *Pancreas*, or sweetbread, lies close to the spine, and near the left kidney; it secretes a fluid resembling saliva, which is discharged into the intestines close to the hepatic duct. It serves to dilute the contents of the bowels, and furnish it with soda.

The spleen. The *Spleen* is a peculiar organ loosely attached to the stomach: it does not secrete any fluid, but appears to be a reservoir for blood.

The kidneys. The *Kidneys* are two glands closely attached to the lumbar vertebræ, and the psoas muscles. They are largely supplied with arterial blood, from which they separate the urine, which is conveyed to the bladder by long tubes called the ureters. The urine, it is well known, abounds with ammonia, a compound consisting largely of nitrogen, which is derived from the transformed tissues arising from the waste the body is continually undergoing. Its properties are alkaline, whilst that of carnivorous animals possess acid properties.

Gastritis. Gastritis, or inflammation of the stomach, is a rare disease in the horse, and when it does occur it is most frequently produced by poison; it now and then, however, appears as a natural disease. Its usual symptoms are a dull, heavy appearance, loss of appetite, hot mouth, swollen eyelids, abdomen enlarged, bowels rather costive, pulse oppressed and ranging from fifty to sixty. This stage is sometimes followed by one of excitement, in which the pulse is increased in frequency, and the febrile symptoms are more marked; and this stage may be again succeeded by stupefaction. There is not the acute agony of inflammation of the bowels, but it is evident that there is a constant pain of a more subdued character. The disease may be produced by anything that disturbs the digestive functions, and it is attended with considerable danger.

The *Treatment* must consist of copious blood-letting, oily laxatives, injections, plenty of diluents, such as linseed tea, and stimulating externally the region of the stomach, and afterwards administering vegetable tonics. If there is reason to suspect that the animal has had poison administered, we must endeavour to ascertain the nature of the poison, and apply without delay the best antidote. If arsenic has been taken, lime-water and mucilaginous liquids, in large quantities, should be given, and bleeding avoided, as being calculated to encourage absorption, but endeavours should be made to subdue the inflammation by other means. If corrosive sublimate has been taken, the white or albumen of eggs should be given suspended in water, as this renders the sublimate insoluble. If the preparations of lead have been given, Epsom salts with linseed oil and gruel should be administered. For sulphate of copper the best antidotes are soap, oily purgatives, and gruel. For the strong acids, chalk, magnesia, and soap, and large quantities of liquids should be given. When Poisons death takes place, we usually find, if a mineral poison is the cause, that the stomach as well as the intestines are eroded, ulcerated, and inflamed. If gastritis proceeds from natural causes, and terminates fatally, the stomach is greatly inflamed, and a thick coat of blood is sometimes effused under the mucous membrane.

Inflammation of the stomach may exist in a sub-acute form, but very rarely; and cancer and scirrhus in this viscus are still more seldom met with.

Stomach staggers. Stomach Staggers, or the mechanical distension of the stomach with food, is now a very rare disease compared to what it once was. This favourable alteration may be attributed to the much better system now pursued in the feeding of horses; they are not kept without food so long as used to be the case with agricultural and waggon-horses. Indigestion may either be the cause or the consequence of the distension. When the stomach is empty, and a large quantity of food half masticated is hastily consumed, indigestion is the natural consequence; but the powers of the stomach may be sufficient to overcome the indigestion, or it may induce the torpor and other symptoms of stomach staggers. On the other hand, indigestion occasioned by deleterious substances may precede, and render the food productive of distension. Some years since this disease proved dreadfully fatal in Wales, and produced great havoc amongst the horses employed in the mines; but in England the attacks have usually been solitary or confined to a few cases. It was, however, of somewhat frequent occurrence on undrained moors, and was there ascribed to eating the weed called rag-wort, or stagger-wort, as it was locally denominated.

The *Symptoms* are, great heaviness and drowsiness; the horse rests his head against the manger, or forces it against the rack or the wall, standing with his fore legs much under him. These symptoms would appear to denote disease of the brain, but there is such an intimate nervous communication between this organ and

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the stomach, that it becomes affected by sympathy. The bowels are costive, the abdomen greatly distended, the urine high coloured, the membranes of the nostrils and the mouth often of a yellow tinge; and sometimes there is a twitching of the muscles of the chest. The breathing is not increased, and the pulse for some time does not greatly exceed the natural standard. There is little or no appetite, but the food is taken and partly masticated, and dropped again from the mouth. These symptoms go on increasing, and the animal may die paralyzed or convulsed, or tetanus may supervene; and sometimes the symptoms of the most violent brain fever may carry off the animal.

The *Treatment* must be regulated by the symptoms and condition of the horse. If the abdomen is greatly distended and feels hard, we may rightly conjecture that the stomach is loaded with food; if, on the other hand, the abdomen is of moderate size or tucked up, then the cause may be in the brain, or there may be indigestion, but without much mechanical distension. In the former case our utmost efforts must be employed in relieving the overloaded viscus. Croton oil, 30 drops may be given with a pint of linseed oil and 2 drachms of ginger; and moieties of the two latter medicines may be repeated several times. Injections should be thrown up frequently so as to relieve the bowels. Bleeding may be practised, but in moderation, and the abdomen may be fomented externally. Spirits of nitrous ether and the liquor ammonia acetatis, an ounce of the former and two of the latter should be given twice a-day; and when the bowels are relaxed, vegetable tonics will be found advantageous. If the symptoms of excitement should succeed those of torpor, profuse blood-letting may be had recourse to. If indigestion appears to be present, but without distension, we must then endeavour to restore the tone of the stomach by mild laxatives, diffusible stimulants, and vegetable tonics.

Colic or Fret

SPASMODIC AND FLATULENT COLIC—*Fret—Gripes.*—These various terms are employed to designate a disease which is very common in the horse. It may proceed from indigestion, drinking cold water, or eating green food. There are several varieties of the disease; for instance, *Flatulent colic*, which is the most frequent, is distension of the stomach or bowels with the gases produced by the fermentation of the ingesta, and often arises from eating green food. *Spasmodic colic* is violent spasms or contractions of the muscular coat of the bowels, and often proceeds from a large draught of cold water, particularly if it be hard. *Stercoral colic* arises from indigestion and the mechanical interruption caused by an accumulation of food. The *symptoms* of the two former are pretty much alike, and are characterized by the exhibition of the most violent and acute pain; the horse paws his litter, lies down, rolls on his back, looks round on his sides, rises again, and continues suffering the most violent agony for some time, with occasional intermissions of ease. In flatulent colic the abdomen is distended; in spasmodic, it is not. There is generally an incapability of passing the urine, which induces the attendants to suppose that the pain arises from this inability to stale; but this is not the case, for sometimes the horse is relieved from the most violent pain in a very few minutes, and then, the stomach and bowels being eased, the horse stales readily, and this is one of the earliest and most decided symptoms of improvement. The neck of the bladder probably sympathizes with the bowels. The pulse for some time is but little, if at all, increased in frequency, and if it is so during a paroxysm, it quickly subsides on its remission. This is very essential to observe, as it affords the most important means of discriminating between colic and inflammation of the bowels; but, in addition, we may observe, that in the latter disease there are no intervals of ease, and there is often coldness of the extremities. In stercoral colic the symptoms are by no means so violent, but more constant and long-continued.

The *Treatment* must consist in the immediate administration of an anti-spasmodic; some give spirits of turpentine with linseed oil, but, though often successful, there is some danger of producing inflammation, which it is better to avoid, or of inflaming the throat if the horse retains it there for some time, as is frequently the case in this disease. Hartshorn is subject to the same objections; in the absence of other agents, however, they may each be given, and then the dose of the former is from two to four ounces; and the latter one or two. In the same manner a quarter of a pint of brandy or gin, or one ounce of ginger dissolved in water may be often successfully employed. A better remedy than any of these, however, is the tincture of opium, an ounce of which may be combined with one of tincture of myrrh or valerian and two of spirit of nitrous ether; or, if there is flatulency, six drachms of sulphuric ether, and given with a pint of tepid water. If relief is not obtained in the course of an hour, the dose should be repeated, and the horse bled, and that and any subsequent doses had better be given with a pint or more of linseed oil. In stercoral colic we must not expect immediate relief, and it is better to bleed early and give large doses of linseed oil with tincture of opium, repeating the dose every three or four hours, and assisting the action of the oil by frequent and copious injections of warm water. By this treatment we shall generally succeed in removing the obstruction and the pain. There is much less danger attending the profuse purging which afterwards succeeds than if it is produced by aloes; plenty of thick gruel must, however, be administered, to which a few drachms of gentian and ginger may be added.

Enteritis.

INFLAMMATION OF THE BOWELS (*Enteritis*).—It is important to distinguish this disease from that last described, as there is some essential difference required in the treatment. It consists of inflammation, principally, of the muscular coat of the bowels, and it causes the most acute and severe pain. The horse lies down, looks round at his flanks, groans, sweats, rolls and plunges about, and gets up again, and thus continues with but slight, if any, intervals of remission. There are, in fact, no paroxysms, as in colic; there is no relief from pain, though the agony may not be at all times alike. The extremities soon get cold; there is an absolute loathing of food; the pulse is exceedingly quick; at first somewhat full and hard, but it soon becomes small and wiry; and except at the onset of the disease, the blood is of a dark colour. The causes of enteritis are cold applied to the abdomen, either externally or internally, long-continued and rapid exertion, and indigestible or improper food, or indigestion from other causes.

*Treatment.*—There is no disease that requires more prompt and energetic attention than this. In the first instance a large opening should be made in the jugular, and if the blood does not flow rapidly, a similar open-



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ing on the other side of the neck. With the finger on the pulse, we should abstract as much blood as the animal can bear, continuing the operation till the pulse is scarcely perceptible, by which time from six to eight quarts will probably have been abstracted. The following draught should next be administered—powdered opium a drachm and a-half; tartarized antimony, one drachm; spirit of nitrous ether, one ounce, which having been mixed together, a pint and a half of linseed oil may be added. Injections of warm water should be frequently thrown up, the extremities bandaged with flannel, the warmth having been previously restored by means of hand-rubbing and a liniment of oil and turpentine. The abdomen should be fomented with hot water for a long time together, by means of long woollen cloths held by two men, one on each side of the horse; the cloths should not be very wet, but being wrung by the men, they should be applied to the abdomen for several minutes at a time. The bleeding, if required, should be repeated in the course of four to six hours, and the best sedative will be a ball containing a drachm each of opium and calomel, which may be given every six hours. The horse should be encouraged to drink warm water and tepid gruel, and thick oatmeal or linseed gruel may be given as a drench from time to time. If constipation continue, the oil, in half doses, must be repeated. When the horse gets better, no corn and very little hay should be given for several days, but plenty of bran mashes. He will require much care and attention, and should not be put to his work too soon.

Strangulation of the bowels.

*Strangulation of the Bowels* sometimes produces symptoms very similar to those we have described under the head of enteritis. It is in fact inflammation of the bowels, but confined to a more limited space. There are various kinds or causes of strangulation—sometimes the guts become entangled and twisted into a knot, at others the mesentery is ruptured, and the part separated forms a noose, through which the bowels pass when empty, and afterwards becoming distended with food or wind, strangulation is the consequence. Sometimes one portion of the intestines becomes insinuated into another, causing *inter-vagination*. These morbid changes may either be the consequence of the violent motion of the bowels in spasmodic colic, or it may arise from accidental or natural causes, which produce all the symptoms that we notice from the beginning. When spasmodic colic becomes fatal, it is most frequently from strangulation of the intestines supervening. The earlier symptoms of strangulation resemble those of colic, but without any remission of pain; it thus differs from enteritis in the rapid pulse, and other marks of inflammation not being present at first, but gradually and fatally developed afterwards. It must be evident, though it is impossible to pronounce decidedly that strangulation has taken place, that when it is so, all treatment will be fruitless.

*Hernia*, or *Rupture*.—It consists in the escape of a portion of the intestines from the abdomen. When this takes place through the abdominal ring, it is called *scrotal* hernia in the horse, and *inguinal* hernia in the gelding. Sometimes it is *congenital*, appearing at birth, and this may also be the case with abdominal hernia; but it is more frequently produced afterwards by external injury, such as a hook from a cow, which ruptures the abdominal muscles, but not the more elastic skin. Scrotal hernia sometimes becomes strangulated, when the utmost agony is produced, and if relief is not speedily obtained, death is sure to follow. No time therefore must be lost, but the horse being thrown, attempts should be made to reduce the hernia by manipulation with the hands (the *taxis*), a powerful opiate, with blood-letting having been previously employed. If this fails, the scrotum must be opened, the stricture carefully enlarged, the intestine returned, and the testicles removed. In congenital scrotal hernia, the intestine should be returned into the abdomen, and the colt castrated by the caustic clams without cutting into the vaginal sac. Abdominal hernia may often be cured by pressing in the intestines, and tying a strong ligature closely round the skin, which, sloughing off, leaves a cicatrix, which prevents the re-escape of the bowels. In more extensive cases, a cure has been accomplished by cutting through the skin, reducing the rupture, and preventing its return by strong metallic sutures connecting together the lacerated muscles.



Calculi in the intestines.

*Large stones* in the intestines sometimes produce stoppage, inflammation, and death. Millers' horses are most subject to this disease, and the appearance of the calculi shows that for the most part it consists of the powder from the millstone intermingled with the food; this is taken with the bran, which usually forms a larger portion of the diet of such animals. Horses so affected are frequently subject to colic, but usually get relieved after a while, either with treatment, or by the stone becoming dislodged by the struggles of the animal. The *symptoms* resemble those of colic; but there is obstinate constipation, and if the stone is in the large intestines, as it generally is, unless it is in the stomach, the horse will sometimes sit on his haunches like a dog. He should be copiously bled, and opium, with large doses of oil administered, the former to relieve the pain, and the latter to promote the evacuation of the calculi which, if not too large, may sometimes be accomplished.

Rupture of the intestines.

*Rupture* of the intestines now and then occurs; the symptoms resemble enteritis of the worst kind, but with greater loss of strength and pulse, and it becomes fatal often in the course of twelve hours; the horse will also sometimes sit on his haunches.

*Inflammation of the mucous coat* of the bowels is not so common as it used to be, when the enormous doses of aloes, and other purgatives of which we read in old books, were commonly administered. This leads us to the most frequent cause of the disease, which is an overdose of purgative medicine. The horse, either from its vast extent or other causes, is very liable to inflammation of the mucous coat of the intestines. It is indeed one of the peculiarities of the animal, and renders purging a much more serious affair than in man, and occasions a small dose of aloes to be so dangerous in affections of the lungs. There are, however, several stages or varieties of disease in this coat. We may have simple *diarrhœa*, which is purging without inflammation; or *dysentery*, vulgarly called molten grease, in which large flakes and masses of fatty-looking mucus is discharged with the fæces, which may either be hard or relaxed. This disease appears to be subacute inflammation of the mucous membrane. Diarrhœa should be treated with opium, 1 dr., powdered chalk 2 oz., catechu 2 drs., and ginger 1 dr., with wheat-flour gruel, keeping the body warm and comfortable. *Dysentery* requires the oily

Dysentery.

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laxative, together with the calomel and opium ball previously advised, with plenty of linseed tea or other diluents.

Super-purgation. *Super-purgation* from actual inflammation, is extremely dangerous; it is attended with coldness of the extremities, weakness, and pain; the horse lying down, looking round at his flanks, and feeling greatly distressed; the pulse is small and thready, and the membrane of the eyelids and nostrils of a deep red or orange colour. It is necessary to avoid bleeding, at any rate until the pulse becomes much more distinct and stronger. The following draught should be administered as early as possible. Powdered opium 1 dr., prepared chalk 4 oz., acacia gum 1 oz., carefully dissolved in warm water, and given with plenty of oatmeal gruel, which, alternated with linseed tea, should be often repeated. The legs should be bandaged, and the abdomen fomented with hot water. The medicine, or one half of it, may be repeated, if necessary, in a few hours; and when the purging appears to be stopped, half a pint of linseed oil should be given to prevent constipation, which, as the sequel, is attended with danger. Unless the symptoms can be relieved early, the disease becomes fatal, sometimes in the course of twelve hours; and the inside of the intestines discovers traces of extensive disease, being often completely black. This disease is more frequent than enteritis, and, like it, may be produced by over-exertion and exposure to cold. Some horses are much more disposed to it than others, and particularly those with light carcases.

Peritonitis. *Peritonitis*, or inflammation of the peritoneal coat of the bowels, is extremely rare in the horse. When it does occur, it usually proceeds from castration, the inflammation spreading from the scrotum through the abdominal rings, which in the horse continue open to the abdomen, and then it is frequently fatal. It also sometimes accompanies pleurisy, the membrane attacked being the same in both these diseases.

The *Treatment* must be regulated by the symptoms, and should be nearly similar to that advised for enteritis.

Ascitis. Dropsy of the abdomen is still more rare in the horse; it is the effect of subacute inflammation of the peritoneum, and should be relieved by tapping.

Worms. *Worms.*—There are various worms which are found in the intestines of the horse. *Bots* are the larvæ of the gad-fly, of which there are two species, which deposit their eggs on the skin. These eggs are swallowed by the horse, and are hatched in the stomach, where they remain fixed by their hooks for the greater part of the year, and are then excreted with the food, and take the form of the parent fly. They are seldom injurious. The *Teres*, or round worms, as well as the thread-worm *Ascaris*, are very common in horses, particularly in those that are poorly fed, and in bad condition. The latter occasion the most irritation, and are principally found in the cæcum. If the horse appears in good health and condition, it is well to let the worms alone, but if otherwise, we may have recourse to some means for their expulsion. A drachm of tartarized antimony, or six grains of arsenic, combined with vegetable tonics, and given daily for a week, and followed with a pint and half of linseed oil, will often succeed in removing them; or three ounces of spirits of turpentine, with the above dose of oil, and followed with tonics, has also been exhibited with success.

Diseases of the liver. DISEASES OF THE LIVER are much less frequent in the horse than in man, owing probably to the more regular manner in which the former is both fed and worked. If, however, a horse is very highly fed, and very little exercised, the system becomes loaded with carbon, which cannot get relieved through the usual outlet—the lungs, as the horse does not respire sufficiently, nor consequently absorb sufficient oxygen to combine with the carbon that is ready to be excreted. Much of the superfluous carbon is converted into fat; but what cannot be so converted is thrown on the liver, and disease of this organ is the consequence. In warm weather there is much less oxygen required for keeping up the animal heat, and there is consequently less oxygen absorbed, and less carbon expired; thus it is that animals are more disposed to get fat in the summer than in the winter, and more liable for the same reason to diseases of the liver.

Jaundice. *Jaundice*, or the yellows, is an extremely rare disease in the horse. There being no gall-bladder, there is less danger of obstruction from gall-stones, or other causes, and therefore the bile is rarely absorbed into the system, colouring the membrane of the eyelids and nostrils with a yellow tinge, which is the principal symptom of the jaundice in the human subject. When the membranes are so tinged, it is generally the consequence of—

Hepatitis. HEPATITIS OR INFLAMMATION OF THE LIVER.—The *symptoms* of this disease are less marked than in inflammation of the lungs, but they depend very much on the acuteness of the attack. In the acute variety, we have a quick pulse, ranging probably between 50 and 70, and firm and regular. The respiration is also increased, but without the distressed appearance of pneumonia, and the horse prefers a standing posture, but not obstinately, as in that disease; and as the inflammation advances, he will lie down and get up frequently. The mouth feels hot, and there is no appetite. These symptoms do not all make their appearance suddenly, but the disease has probably been creeping on for days before the horse has been thought to be amiss. The yellowness of the eyelids and mouth, in addition to the other symptoms, testifies the nature of the malady, which is otherwise obscure. It is a very dangerous complaint, and is not unfrequently fatal, and it often occurs in connection with other diseases, and more particularly with the *Influenza*, the danger of which it greatly increases. The sides, and particularly the right, is tender on being pressed, and the fæces are hard and coated with mucus, and sometimes fœtid and purging. When the symptoms are unrelieved, they all become more urgent; the pulse quicker, weaker, and vacillating, and the animal dies in the course of ten or twelve days.

The *Treatment* must be less active than that advised for pneumonia, and particularly with regard to bleeding. From three to five quarts will usually be sufficient at first, and two or three on repeating the operation. The following draught should be given:—Carbonate of potash 2 drs., aloes 2 drs., dissolved in hot water, and then well shaken up with 12 ozs. of linseed oil, and 1 dr. of calomel; to be repeated twice a-day, without the aloes, until the bowels are moderately relaxed, and to be assisted by raking and injections. If there are symptoms of pain, 1 oz. of tincture of opium may be added to the above.

The sides should be well blistered opposite the region of the liver; and when the bowels are relaxed, the following should be administered every twelve hours:—Opium ½ dr., calomel 1 dr., resin 3 drs., carbonate of



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potash 2 drs.; to be made into a ball with soft soap. Vegetable tonics may afterwards be given in combination with the above, or alone, as the symptoms may intimate.

Chronic hepatitis.

*Chronic Inflammation of the Liver* is attended with symptoms more obscure than those last mentioned, but of the same character, and a dull heavy appearance: the animal should be treated on the same principles, but bleeding must be very moderate, or altogether omitted.

Enlargement of the liver.

*Enlargement of the liver* is an obscure disease, and creeps on without attracting attention. The symptoms are, enlargement and hardness of the abdomen, bowels either constipated or relaxed, pulse remarkably rapid, and loud and thumping, as in disease of the heart. The *Treatment* should consist of laxatives, calomel and opium, and counter-irritation, and afterwards vegetable tonics; to these the iodide of iron, in doses of a scruple, may be added.

Hepatirrhœa.

Closely connected with this disease is HEPATIRRHŒA, or rupture of the coats of the liver, and hæmorrhage from it. Old horses are chiefly affected, and the rupture is preceded by structural disorganization, similar to that last described. The *symptoms* vary according to the amount of the rupture and the loss of blood, and whether it be merely effused under the peritoneal coat of the liver, or whether the coat is also broken, and the blood escaped into the abdomen. In the latter case, the loss is considerably greater, and the horse paws, shifts his posture, sighs, curls the upper lip, tosses his head, and exhibits great debility, and partial or total blindness; the pulse is exceedingly quick and feeble, and the membranes blanched. Death occurs in the course of a few hours; and on examining the horse, a considerable quantity of dark blood is found in the abdomen, and various rents in the liver, from which it escaped. This viscus is greatly enlarged, weighing sometimes upwards of sixty pounds; the increased size consisting for the most part of effused and coagulated blood. The structure of the liver is readily broken down, and it is of a fawn or brown colour. If the hæmorrhage is but moderate, or simply under the peritoneal coat, the symptoms are much less urgent, though of the same character, and the horse may rally and apparently recover, only however to sink under the disease at some future time, though perhaps not till after several attacks. The partial or total blindness is a frequent, and sometimes one of the earliest symptoms: the retina becomes gradually insensible to light, and paralysis and amaurosis take place. This may occur first in one eye, and then in the other, and in this case the first attacked, either may or may not be restored to sight. As the animal gets better from an attack, the urine becomes of a dark brown or black colour from the presence of carbonaceous principles, which are thus carried out of the system.

*Treatment* in this disease can be of little avail; bleeding, however, should be avoided, and preparations of turpentine, copaiba balsam, and alum, may be given; one ounce of the two former, and a drachm of the latter.

Decayed structure of the liver.

Another disease of the liver, and of a very insidious and destructive character, and by no means uncommon occurrence, may, in the absence of a more appropriate name, be called *Decayed structure*. It often precedes or accompanies other diseases, and greatly increases their danger, sometimes causing blood-letting, or a dose of physic, which would otherwise have been harmless, to produce a fatal effect; and then the liver is found to be of a yellow-brown colour, and sometimes so disorganized as to be easily separated from its covering, and, in fact, a pulpy mass. The *symptoms* are very uncertain and obscure, for the horse may look sleek and fat, although the liver may be dreadfully disorganized. The eyelids and mouth, however, will usually have a yellow appearance; the appetite will be impaired, and faintness and dulness be present. The fæces are usually soft, showing that indigestion exists; and the pulse is as slow, or slower, than usual. Bleeding should be avoided in this disease, and much caution otherwise exercised. Calomel and opium, and aloes, of each one drachm, should be given once a-day in a ball, combined with three drachms of resin. This treatment should be continued for four or five days, and may be followed by mild tonics, regular exercise, and wholesome but not too rich food.

Nephritis.

The *unhealthy* secretions of the liver is sometimes the cause of excessive purging, when the pulse is rapid in the extreme and the debility very great. Such cases should be treated as advised for *super-purgation*.

INFLAMMATION OF THE KIDNEYS (*Nephritis*) is not a frequent disease in the horse. The *symptoms* are, considerable pain and distress, very quick pulse, an increased respiration, hot mouth, and other tokens of fever; the horse flinches on the least pressure applied to the loins, and the urine is of a very dark and almost black colour. It may be produced from a strain across the loins, exposure to cold and wet, and too strong or too long-continued diuretics.

*Treatment.*—Copious blood-letting, repeated if necessary, oily purgatives, stimulating the loins with the iodide of mercury ointment, and applying afterwards a sheep-skin just taken from the sheep's back, the woolly side outwards. The skin should be replaced by another when it begins to smell offensively. Diuretics should be avoided, but sedatives will be very beneficial. A scruple of hellebore twice a-day in a ball, till nausea is produced, has been employed in this disease with much advantage, but requires to be carefully watched. A drachm each of calomel and opium is also very suitable. Injections of warm water should be frequently thrown up, and the diet should consist of mashes and green food.

Injuries of the loins.

*Injuries of the Muscles* of the loins, from strains or other causes, and giving rise to many of the symptoms above described, although there may not be any actual inflammation of the kidneys themselves, should, however, be treated in the same manner.

Cystitis.

INFLAMMATION OF THE BLADDER (*Cystitis*) is a still rarer disease than that of the kidneys. The symptoms are great pain and fever, with their concomitants and a continued desire to stale. No sooner is urine conveyed to the bladder than it irritates the inflamed mucous coat of this organ, and prompts its immediate and forcible discharge. This disease is more dangerous than that last described.

*Treatment.*—Extensive bleeding, repeated if demanded. Oily laxatives, sedatives, but no diuretics. Sheep-skin applied to the loins and to the abdomen if possible, or frequent hot fomentations to the latter. Sometimes the neck of the bladder is principally inflamed, in which case the urine is obstinately retained, and in some instances the bladder has been ruptured. This is more likely to occur in the horse than in the mare; whilst the latter is more liable to inflammation of the bladder itself. The treatment should be pretty nearly

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alike in both instances; but in the mare we are able to inject mucilaginous liquids into the bladder, whilst in the horse it is scarcely practicable. Linseed tea, made thin, with a few grains of opium dissolved in warm water, should be gently injected into the bladder two or three times a-day; and injections should be thrown up the rectum, which will act in some degree as a fomentation.

Spasm of the neck of the bladder. *Spasm of the neck* of the bladder is by no means uncommon, particularly in the horse; it has already been stated that this affection frequently attends spasmodic colic, but then it appears to arise from sympathy, and is removed when the bowels are relieved. The most usual cause is travelling a long distance without being allowed to stale. The urine accumulates in the bladder, and the sphincter muscle which closes its neck having been so long in violent action, it is thrown into a state of spasm and cannot be relaxed. The nature of the disease is shown by the frequent but ineffectual attempts at passing the urine, and the absence of those feverish and other symptoms which denote the accession of inflammation. In the mare relief can at once be attained by passing the catheter into the bladder; but from the difficulty attending this operation in the horse, other means should be previously tried. In the first instance the horse may be bled, then an ounce and a half of tincture of opium and spirit of nitrous ether should be given with a pint of warm water. The bladder should be examined per rectum and the fæces removed at the same time, and gentle pressure used on the bladder, so as to encourage and assist the effort of staling. Clysters of warm water should be thrown up, and if these means fail, we must then have recourse to the elastic catheter, made with twisted wire and caoutchouc. The penis being drawn out at its full length and grasped with the left hand, the catheter, which has been oiled, should be gently forced up the urethra until it passes the angle at the perineum and enters the bladder. The whalebone stilette should then be withdrawn, and the urine will pass through the tube.

Diabetes. *Diabetes*, or excessive staling, is generally owing to the disturbance of the digestive organs and foul provender. It is attended with thirst and fever, and is best treated by moderate purging, mineral and vegetable tonics, and iodine.

Urinary calculi. *Urinary Calculus* in the horse is more frequently found in the kidneys than in the bladder, and may exist there for years without its being known or suspected. In man, it is generally found in the bladder, which is owing to his erect position favouring the descent of the stone by its gravity. When it occurs in the bladder of the horse, it occasions much uneasiness, and frequent efforts to stale, the act being painful; and sometimes a few drops of blood are passed with the urine. The stone may occasionally be felt, by passing the hand up the rectum, but still better if the animal is thrown and turned on his back.

Lithotomy. Almost the only method of relief is by the operation of *lithotomy*, which consists in passing a grooved staff up the penis (the horse being cast and turned on his back), until it can be felt at the perineum, where it is cut down upon, and the opening being enlarged by the *bistouri caché*, the forceps is passed into the bladder, and the calculus grasped and removed. Tepid water should be injected into the bladder, so as thoroughly to wash out its contents, and the wound sown up, and the horse released. This operation requires much anatomical knowledge and surgical skill, and though the necessity for it seldom occurs, it has been performed successfully in various instances by the Professors of the Veterinary College and others. The urine will be discharged for some little time through the wound, which will heal gradually, the horse requiring care for several weeks. Calculi have been removed from the mare without this operation, but through the natural opening, by means of the forceps, one hand being kept in the vagina, so as to guide the stone.

Castration. *Castration.*—The usual method of performing this operation is to open the scrotum with the knife, put on the clams, and divide the spermatic cord with a hot iron. Another plan is to divide the cord with the knife, tying the vessels, or stopping the bleeding by *torsion*. On the Continent it is customary to place the cord between two elder sticks, tied together, and enclosing a caustic paste, and remove the testicles in a few days. This may be done without cutting into the vaginal sac, but enclosing it with the cord.

Diseases of the brain. Phrenitis. DISEASES OF THE BRAIN are far less frequent than those either of the chest or the abdomen, and are comparatively much rarer than in the human subject. PHRENITIS, or inflammation of the brain, vulgarly called *mad staggers* is occasionally met with, and is ushered in with symptoms of heaviness, dulness, and unwillingness to move, diminished appetite, and redness of the membrane of the eyelids, &c. These appearances frequently escape observation, which, however, is quickly awakened by those of madness or delirium, which suddenly supervene. The horse plunges about the stall or box with the greatest violence, and will bite his attendants or other horses, rendering it somewhat dangerous to be with him. After exhausting himself by struggling, he will lie or fall down, the violence, however, returning with his strength. The disease consists of inflammation of the brain, and though somewhat resembling rabies, and stomach staggers, may yet be distinguished from them. There is no method in the madness, as in rabies, and with more violence, there is less actual disposition for mischief. In stomach staggers there is generally an inclination to force the head forwards against the rack or other object, and there is a longer duration of the previous stage of dulness than in phrenitis. The cause of this disease may be considered to be too high feeding, and want of sufficient exercise, producing a too great fulness of the vessels or plethora.

The *Treatment* should consist of immediate and profuse bleeding, either from the neck or the temporal arteries, or any large vein that may be more readily opened. The bleeding should continue until the delirium ceases, the pulse falters, or the animal exhibits signs of fainting. More blood can be abstracted in this disease with impunity and advantage than any other, two and three gallons having sometimes been abstracted. Next in importance to bleeding is purging, a strong dose of physic should be given, either in a ball or a draught; the latter is the quickest in its action, but the former is the more certain, and its operation should be assisted by frequent injections. If the animal gets better, the diet should be restricted for some time.

Megrims. MEGRIMS or *Vertigo* is more frequent than phrenitis; it comes on suddenly, and appears to arise from sudden determination of blood to the head, produced by the pressure of a tight collar, or severe exertion, assisted by the predisposition of the animal, which in some

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instances is so great as to render the horse of very little value. The animal will suddenly stop, shake his head violently, reel from one side to the other, and sometimes recover, and at others will fall and struggle for some time with great violence. The *Treatment* consists in immediate bleeding, and giving afterwards a dose of physic.

Rabies. RABIES or *Canine madness* is invariably produced by the bite of a rabid animal, the poison being communicated by the saliva.

The *symptoms* very much resemble those of phrenitis, but with somewhat less violence: there is a greater disposition for mischief. There is not the reckless abandonment of phrenitis; the intellect of the animal is not impaired, but his destructive and combative propensities are more violently excited. One of the most striking symptoms of its approach is a spasmodic movement of the upper lip, and particularly at the angles. Convulsions of different parts of the body succeed, and the horse often fancies he sees some imaginary object at which he will rear. To this succeeds the propensity for mischief, and the state of extreme violence, in which he will often level or destroy all surrounding objects. This generally terminates in paralysis, under which he sinks in the course of three to six days. All treatment after the symptoms have once been developed is fruitless; but if the bitten spot can be discovered, we may succeed in preventing the disease. The writer has operated successfully on various horses that had been bitten by a rabid dog, by carefully applying the nitrate of silver to every part that exhibited the slightest appearance of the bite: if the bitten part can be afterwards conveniently excised, it will render the operation still more secure. The disease is generally developed from six weeks to three months after the bite, and sometimes much longer.

Paralysis. PALSY or *Paralysis* is of two kinds,—*Hemiplegia*, which is paralysis of one side of the body, and *Paraplegia*, which is palsy of the hind extremities. The former is very rarely met with in the horse, the latter is much more frequent, and generally arises from sudden injury of the spinal marrow at the region of the loins, such as a severe fall in hunting, or keeping back a loaded waggon; and it may also be produced by a tumour pressing on the nerves which supply the hind extremities. The former may or may not be accompanied by fracture of the vertebræ, and the latter is generally gradual in its approach. The *treatment* should consist of venesections, laxative and febrifuge medicines, and the application of sheep-skins, and stimulants to the loins. It however frequently happens that although the horse gets better, he is permanently weak in the loins, "chinked in the back" as it is termed, and of no use, except for the lightest work. A disease very similar to this is common in India, and is there called *kumree*.

Kumree. Tetanus. TETANUS, commonly called locked-jaw, though this is but one of its symptoms, is not uncommon in the horse. It consists of violent spasm of the muscles of the body; if confined to the head and neck, it is called *Trismus*, which is more manageable than when the greater part of the body is convulsed. When it is produced by a local injury, such as a broken knee, a prick from a nail, or docking, or nicking, it is called *Symptomatic*, or *Traumatic;* and when from other causes, such as exposure to wet and cold, or internal disease, it is denominated *Idiopathic*. Spasm of the muscles of the jaw and neck, so that the former becomes nearly or quite closed, is one of the earlier symptoms, from which it gradually extends, till the back and loins become rigid and fixed. The peculiar appearance of a tetanic horse cannot be mistaken—the spine is immoveable, the head poked out, neck stiff, nostrils distended, ears and tail erect, and eyes often distorted; the muscles, thus cramped, feel hard as a board, and the whole aspect of the animal is one of the greatest distress. The nervous system, it is evident, is in a state of the highest excitement; and on the least noise being made, the animal is greatly alarmed, and the respiration much increased and disturbed. The pulse is usually full, and not much quickened. On examining fatal cases, the viscera are often found greatly inflamed and diseased; and the brain and its envelopements, as well as the spinal marrow, frequently exhibit traces of inflammatory action. Various methods of treatment have been recommended and adopted for this severe and fatal disease, and all with occasional success, but more frequent failure.

*Idiopathic* is more curable than *traumatic* tetanus, and has most frequently yielded to copious bloodlettings, and purgatives, with opium, and camphor, exhibited by the mouth if possible in doses of a drachm each, and also in the form of injections: croton oil forty drops, or aloes, eight drachms of which will not be too strong a dose, as there is much torpor of the bowels. Blistering applications to the abdomen have also proved of much service, and if the disease has arisen from an injury, the cauterization, or removal of the part, or the destruction of its sensibility, by dividing its sensitive nerve, has assisted in the cure.

Rheumatism. SPECIFIC DISEASES.—It used to be denied that the horse was subject to rheumatism, but there now can be no question as to the fact, both as regards the acute and chronic kind. The former is commonly termed a *chill*, and arises indeed from exposure to cold, and its reaction. The *symptoms* vary with the muscles that are attacked; if those of the chest, there is very rapid respiration in addition to the other symptoms. In all cases there is great pain, unwillingness to move, considerable fever, the pulse very quick, strong, full, and hard; and the blood, when taken, as we might anticipate from the pulse, is covered with a thick buffy coat, which together with the character of the pulse, is characteristic of the disease. Notwithstanding the great pain and fever, the appetite is but little impaired. The disease is essentially an inflammation of the fibrous tissues, and it may and does fly about from one part to another, but still attacking the same tissue: thus it may affect the fibres of the muscles, the sinews and the ligaments, the bones and their envelopments, and thus it may accompany pleurisy, or precede or succeed it.

*Treatment.*—Copious blood-letting and repeated, oily purgatives, diffusible stimulants, diuretics, stimulating liniments rubbed on the affected parts, together with the application of sheep-skins, particularly if the loins are affected. The shoes should be removed from the fore feet, as there is considerable danger of the inflammation flying to the laminæ or *fibrous* tissues of the feet: poultices to the feet will be also calculated to prevent this result. The diet should be light and cooling.

Chronic Rheumatism. *Chronic Rheumatism* sometimes occurs as the sequel of the former disease, or independent of it. In the former instance there are frequently bony swellings thrown out about the joints, and the lameness shifts from one limb to another. In the latter instance there is generally lameness flying about from part to part in

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the most irregular manner, often attacking muscles and sinews, and leaving no external appearance. It is sometimes the result of pleurisy, and the lameness may be either temporary or permanent. The *Treatment* is seldom satisfactory, and must be principally confined to external stimulants, as there are few, if any, constitutional symptoms to combat.

Glanders.

GLANDERS and *Farcy* are two of the most fatal diseases to which the horse is liable; hundreds of animals have been carried off by them, but in consequence of the better stable management and improved ventilation now adopted, these diseases are far less frequent than they formerly were. Glanders is so called from the hard swelling of the submaxillary glands, which is almost invariably found, and is attended with a discharge from the nostrils, somewhat of the nature of pus, which sticks to them, being of a viscid character. This discharge may be either copious or slight, according to the extent of the disease, or the stage it may be in. The disease has been distinguished as Acute Glanders and Chronic. In the former, the discharge is very copious from both nostrils, the glandular swelling is large, and there are frequently ulcers visible on the Schneiderian membrane which lines the nostrils. The pulse is generally slightly increased, and in the advanced stages a snuffling noise is heard when the animal breathes, arising from the obstruction caused by the matter. There is also an unthrifty appearance, hide bound, and deficient condition. In chronic glanders the health is not impaired, or but slightly so; the discharge is generally from one nostril, the left, and the glandular swelling corresponds. No ulcers are visible, and in this state the horse may remain for months, or even years; but at length acute glanders and death succeed. Glanders is undoubtedly a contagious disease. If another horse, or an ass, is inoculated with the nasal discharge, it rarely fails to produce a kindred disease, which, by infecting the whole system, proves fatal in a short time. The inoculated part swells, and the absorbents in the neighbourhood also enlarge, and small abscesses form in their course, thus constituting farcy; but the poison soon reaches the head, and glanders appears. The appearance after death varies with the stage of the disease, for the horse is generally destroyed ere the malady becomes fatal. The membrane lining the nostrils is generally found covered with deep ulcers, which sometimes almost penetrate the thick cartilage called the *septum nasi*, which divides one nostril from the other. This ulceration likewise affects the different sinuses of the head, which are often nearly filled with offensive pus; the turbinated bones are in a carious state, and sometimes the ulceration extends down the windpipe to the lungs, which are occasionally found full of small abscesses and tubercles. In mild chronic cases, the diseased appearances are apparently slight, and confined to a small extent of surface. The causes of glanders are, breathing a confined and unwholesome atmosphere, excessive exertion, bad provender, and contact with a glandered or farcied horse. With regard to the remedy, it must be confessed that, although there are instances of a cure being accomplished, they are so extremely rare that it is only a very valuable animal indeed that will justify the expense of treatment. The sulphate of copper, in large doses, of 4 drs. to an ounce, in a draught, with linseed meal; cantharides 6 to 10 grs., with vegetable tonics, have been found, amongst the host of medicines that have been tried, the most successful in combating this disease, but it too frequently happens, that after a cure has to all appearance been accomplished, the disease again returns with all its former virulence.

Farcy.

FARCY is analogous to glanders, though a different part is affected. It may be produced by glanderous matter, and it may be the cause of glanders. Its usual commencement is generally lameness of one of the legs, usually the hind one, which, on examination, appears to arise from a trifling sore; a swelling takes place which cannot readily be reduced; other sores, or rather small abscesses arise; the absorbent vessels of the limb feel hard and corded, particularly those of the groin. The nature of the disease is now self-evident. It spreads into the system; the fore legs become affected in the same manner as the hind ones; the mischief travels up the neck, attacking the head, and producing glanders and death, if the animal is not previously destroyed.

*Treatment.*—Although the poison appears to be the same, yet farcy is much more manageable than glanders, although, like it, appearances are very deceptive, and the disease often returns. The abscesses or farcy buds, as they are termed, should be opened as soon as they feel soft, and either the hot iron, or some strong caustic, applied to the ulcer. Iodine should be applied externally in the form of an ointment or liniment, well rubbed into the swollen parts, and particularly in the course of the absorbents. The iodide of mercury ointment will be rather too stimulating, but it may be mixed with the simple iodine ointment, viz., iodine powdered 1 dr., lard 1 oz.; mixed in equal proportions. Internally, the following tonic ball should be given twice a-day:—

| | |
|---|---|
| Sulphate of iron | 2 drs. |
| Hydriodate of potash | 10 grs. |
| Ginger | 1 dr. |
| Gentian | 2 drs. |

To be made into a ball with treacle.

The bowels must be regulated by an occasional laxative, and a diuretic ball may be substituted for the above every alternate day. This treatment will in many cases succeed in effecting a cure. The diet should consist of green food or carrots, and about two feeds of corn a-day, and when the horse is convalescent, a month's feed in a good salt-marsh will be beneficial.

Influenza.

INFLUENZA.—The epizootic malady which has received the above designation resembles in many respects the disease of the same name in the human subject. It has not prevailed in this country to any extent since 1840, when its attack was very general, though it is customary with some persons to designate every case of epidemic catarrh as the influenza. This, however, is erroneous; for there are many instances in which catarrh is entirely absent, and therefore we must seek for other invariable characteristics in order to ascertain in what the disease really consists. We always find considerable fever, hot mouth, and quick pulse; the extremities are warm, and, after a few days, swell from serous effusion, which also affects the eyelids to such a degree that temporary blindness is often produced. The pulse is usually soft and weak, and considerable debility is a striking characteristic of the disease. These, therefore, may be regarded as the uniform symptoms of influenza, and in many cases

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they are the only ones that are present, and when such is the fact, the disease, if properly treated, passes through its usual stages, and the animal soon becomes convalescent. In the greatest number of cases, however, there is some local inflammation in connection with the general derangement, which may be either trivial or highly dangerous. The nature and seat of this local affection is very much determined by the season of the year: in the summer, affections of the liver and abdominal organs are most frequent, whilst at other periods the respiratory apparatus is most frequently attacked. In fatal cases of the latter description, the ravages of pneumonia and pleurisy are exhibited in the chest, and in the former the liver is found greatly disorganized. Affections of the air-passages are, however, more frequent than derangements of the abdominal organs; and influenza, attended with catarrh and sore throat, constitute the bulk of our cases. In all, however, we may consider the mucous membranes in a state of irritation, so that they are very quickly and severely acted on, either by sympathy or medicinal agents. It is an undecided point as to whether the influenza is infectious, but we incline to the opinion that it is so; although it must be confessed that its appearance, disappearance, and reappearance are often extremely strange and irregular. One of the earliest symptoms is the failure of the appetite, which is attended or immediately succeeded by a dull listless appearance, and the symptoms of fever before noticed; and soon afterwards the soreness of the throat is developed, if the disease takes this form.

*Treatment.*—If the pulse possesses tolerable strength, we may abstract a moderate portion of blood. The amount, regulated, of course, by the symptoms, in a few instances may be copious, but generally we must be cautious not to abstract too much; from two quarts to four will be usually enough. Though it is desirable to relax the bowels, we must be equally cautious as to this part of our treatment. A pint of linseed oil, or ten drops of croton oil, or half of each combined, may be given with the following diffusible stimulant and febrifuge:—

| | |
|---|---|
| Spirit of nitrous ether | 2 ozs. |
| Tartarized antimony | 1 dr. |
| Nitrate of potash | 4 drs. |
| Warm watere | ½ pint. |

Mix.

This may be given twice a-day without the aperient, omitting the nitre after the second day for a day or two, and adding half a drachm of ginger, and one drachm of gentian. It will be rarely prudent to bleed a second time; but if the eyelids are much tumefied, local bleeding from the angular veins, a few inches below the eyes, will be found extremely serviceable; and in many cases, where from the debility of the animal or the lowness of the pulse general depletion will not be judicious, the local bleeding from the angular veins may be adopted with much advantage. If the legs become engorged, they should be bandaged with flannel, and a few punctures with the lancet will afford much relief. The local treatment must be according to the symptoms. If the throat is affected, it should be stimulated externally with a blistering liniment. In severe cases setons will be useful in the region of the throat, and also in the brisket, if the chest appears affected. Blisters on the sides are also in some cases demanded; and if the liver appears to be diseased, we must adopt in some degree the treatment advised under that head. In cases attended with dangerous inflammation of the vital organs, our treatment must be proportionately energetic; but we must still bear in mind that one great peculiarity of the influenza is debility, and as such our treatment must be more moderate with regard to depletion than we should otherwise be disposed to adopt. The diet should consist of bran mashes, green food or carrots, with a moderate portion of corn. A loose box will be useful, and very moderate walking exercise.



Structure of the skin.

*Diseases of the Skin.*—The skin of the horse, like that of man and other animals, is composed of three distinct coats, the outer of which, termed the *cuticle*, is thin, transparent, and void of vessels and nerves, thus serving as a protection to the vascular parts beneath it. The *cutis*, or true skin, is much thicker, vascular, and extremely sensible, receiving the termination of the sensitive nerves. The hair grows from the cutis, or rather from bulbs planted in it, and pierces the cuticle to appear on its surface. The *rete mucosum*, or mucous net-work, is situate between the cutis and the cuticle, and secretes a pigment, which gives the colour to the skin, being in some of a dark hue, and in very light-coloured horses absent. When the cuticle is injured or destroyed it is quickly restored, without any perceptible difference; but if the cutis is destroyed, and with it the bulbs of the hair, the latter are not restored, as new skin never possesses hair; this is the reason why horses often become so much blemished from injuries of the knees. The growth of new skin, unlike that of flesh, is extremely tedious, owing to the fact that it grows only from the borders of the old skin, where it first appears as a white line, which gradually widens until the cicatrization is complete.

Surfeit.

The diseases of the skin of the horse are by no means numerous. *Surfeit*, as it is commonly termed, is an inflammatory eruption, arising from plethora or some sudden determination or reaction of the blood on the skin, on which pimples appear: they are sometimes attended with itching. Unless the horse is poor, moderate bleeding and a dose of physic will generally remove the disease; but the alterative powder advised in the next page may also be given. Surfeit will sometimes present an appearance very similar to the mange and in doubtful cases may be treated like it.

Mange.

Mange is the most contagious disease with which the horse is affected. It is analogous to the itch in the human subject, and, like it, is owing to the presence of very minute insects called *acari*, which are of both sexes, and pierce the skin and multiply in great numbers. The first appearance of mange is accompanied by itching: the horse exhibits pleasure on being rubbed, and on examination we find numerous small pimples on the skin, particularly on the withers and rump; on removing them, a bare spot of a white colour is perceived, from which an ichorous fluid is discharged, which destroys the hair in the neighbourhood. This and the violent itching inducing a horse to rub himself against any object that he can find, causes the hair to come off. Thus it is that horses which have had the disease for some time are nearly bare of hair, and present a loathsome appearance, particularly when the skin becomes wrinkled and thickened, as it does in chronic cases. *Treatment.*—The disease can only be eradicated by topical applications; and of the various medi-

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caments that have been employed there is none better than the following:—

| | |
|---|---|
| Sulphur | 4 ozs. |
| White bellebore | ½ oz. |
| Oil of tar | 3 ozs. |
| Train, linseed, or olive oil | 12 ,, |

To be carefully rubbed down together and mixed.

This liniment should be well rubbed into every affected part, or, better still, over the whole body, either with the hand, a brush, or a piece of flannel, once a-day for several days, after which the skin should be well washed with soap and water. This treatment may be repeated until the disease is entirely eradicated and the horse no longer rubs himself against other objects, and the following powder should be given daily in the food, or a mash, and continued fur seven or eight days:—

| | |
|---|---|
| Sulphur | 4 drs. |
| Black antimony | 2 ,, |

Mix, adding occasionally half an ounce of nitre, or giving it in the water.

The mangers, racks, clothes, &c., should be well washed with soap and water, and afterwards with a solution of chloride of lime.

Warts. *Warts* are schirrous excrescences, which appear on different parts of the body, and are best removed by the hot iron or the knife. *Wens* are oval or round bodies, found floating loosely under the skin, and they may generally be removed by making an incision through it. An *encysted tumour* is a collection of serous fluid contained in a mambranous sac; one part is generally loose and the other attached to the integuments. They are sometimes found at the poll or the withers, and are then generally the result of pressure, and often terminate in fistulous withers or poll evil. These tumours should be carefully dissected out; and in the same manner should those hard, almost cartilaginous, substances which sometimes appear on the shoulders from continued galls.

Encysted tumours.

Melanosis. *Melanosis* is a description of tumour, though rare in this country, yet extremely common in India, where it usually affects the tails of white horses. On cutting into the tumours they are found to contain a black fluid. Sometimes they exist within the abdomen, and attached to the spine, where the writer has known them produce gradual paralysis of the hind extremities, by pressing on their nerves and vessels. No cure is known, but iodine may be tried internally and externally.

The cellular membrane. The parts immediately beneath the skin principally consist of cellular membrane, which, being elastic, tends to give, with the assistance of the adipose membrane, that softness and resiliency of touch which the horse in good condition exhibits. This membrane is abundantly furnished with a set of vessels called absorbents, which, with the membrane, are the seat of various diseases; the first of these is ANASARCA or *Dropsy*, which, in the horse, is of two kinds, one proceeding from debility, and the other from a plethoric or inflammatory state of the system. Horses with round gummy legs having a superabundance of cellular membrane, are most disposed to this disease, which consists of watery swellings generally of the hinder legs. The nature of this enlargement may be readily ascertained by pressing the fingers on it, when the prints of the fingers remain for some little time, showing that it is of a dropsical or watery nature. This disease may be either severe or mild, gradual in its commencement or sudden. Other parts of the body may be affected as well as the legs. The treatment, unless there is great debility, should commence with blood-letting, with a diuretic ball, such as the following:—

Anasarca.

| | |
|---|---|
| Nitrate of potash | 3 drs. |
| Powdered resin | 4 ,, |
| Oil of juniper | 1 scr. |
| Ginger, powdered | ½ dr. |

Soft soap to form a ball;

and, on the following day, a dose of physic. Puncturing the limb, and fomenting afterwards with warm water will relieve the enlargement, with the assistance of hand-rubbing, bandaging, and walking exercise. In some cases it may be necessary to insert rowels or setons in the thigh. If debility supervenes, tonics may be given with diuretics; and if the weakness at first should be so great as to forbid bleeding, the following draught may be administered:—

| | |
|---|---|
| Nitrate of potash | 1 oz. |
| Ginger, powdered | 2 drs. |
| Gentian, ,, | 4 ,, |
| Sulphate of copper | 2 ,, |

To be dissolved in a pint and half of warm water, ale, or gruel, then adding 2 ounces of spirit of nitrous ether. To be repeated, if required, on the second day. This disease is commonly termed *humour*, and there is another somewhat resembling it, and requiring the same treatment, which, in Scotland, is termed *Weed*, and commences with a very painful swelling of the absorbent vessels on the inside of the thigh and near the groin, which extends downwards, producing considerable swelling.

*Chapped Heels* sometimes accompanies anasarca, or it may occur without it. It is most frequent in the autumn and in wet weather, and horses with white legs are most disposed to it. A thin acrid discharge appears from the wound, and the irritation causes the horse to catch up the affected leg suddenly and with great force, which greatly retards the healing of the crack. The *Treatment* should resemble that advised for anasarca, to which we may add poultices to the heels for several nights, made with linseed meal and a solution of alum and sulphate of zinc; the cracks may afterwards be dressed with tincture of myrrh or some mild astringent powder. Chapped heels.

GREASE, which consists of an offensive discharge from the heels and legs, often proceeds from the diseases before spoken of being neglected. It should be treated in the same manner as that just recommended, but the local astringents must be longer continued. The following will be an excellent powder to apply to the part:—Prepared chalk, 4 ozs.; sulphate of zinc, 1 oz.; charcoal, 1 oz.; armenian bole, 2 ozs.; and to be finely powdered and mixed. Grease.

LOCAL DISEASES.—Under this head we must include the *Diseases of the Eye*; but before we do so, it will be desirable to refer to the structure of this delicate and important organ. It consists of various transparent and opaque coats or membranes, forming chambers which contain watery fluids and a surface for the expansion of the optic nerve. If we plunge a needle through the eye, from the front to the back part, it first penetrates the *conjunctiva*, a thin delicate membrane, which lines every part of the eye and its lids that we can see externally; it next passes through the *cornea*, a strong, transparent, double coat, on penetrating which Structure of the eye.



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the needle enters the *aqueous humour*, which consists of two chambers, one in front and one behind the curtain called the *iris*, one edge or border of which is fixed to the eye, whilst the other, the internal, floats loosely in the aqueous humour. This curtain, which in the horse is of a brown colour, has the power of contraction, so as to admit or shut out the rays of light through the oval opening in its centre called the *pupil*, at the upper and lower borders of which we observe some brown or black bodies peculiar to the horse. The needle next enters the *crystalline humour* or *lens*, which is a convex, transparent body, semifluid in its structure. The transparent cornea, rendered convex by the aqueous humour, serves to admit and refract the rays of light, which is still further accomplished by the crystalline lens, the principal glass of the eye. Its posterior part lies in a cavity adapted to it in the *vitreous* or *glassy humour*, which forms three-fourths of the bulk of the eye, and preserves its globular shape. It is composed of watery fluid deposited in cells, and is denser than the aqueous humour, but less so than the crystalline lens. Around the membrane which covers its posterior and lateral surface is spread the *retina* or expansion of the optic nerve, which is of a pulpy nature, a grey colour, and semi-transparent, and on which the picture of external objects is painted in an inverted position, the impression of which is conveyed by the optic nerve to the brain. Behind it there is a dark substance called the *pigmentum nigrum*, which acts like the quicksilver of a looking-glass, preventing the penetration of rays of light and causing the retina to reflect them. Immediately at the back of the eye, this pigment in the horse is of a bluish colour. This *tapetum lucidum*, as it is termed, enables the horse, by reflecting and economizing the light, to see better during the night than would otherwise be the case. The needle next enters the *sclerotic* coat, which is very strong and dense, and surrounds every part of the eye not externally visible. The *optic* nerves cross each other, and then emerge from the cranium at the bottom of the orbit, pierce the sclerotic coat, and are expanded as before stated. The eye is imbedded in fat, which serves as a cushion to prevent injury, and is moved readily on every side by means of muscles, of which there are four straight ones, one above and below, and each side, and two oblique ones, the upper of which acts like a pulley. In addition to these, which correspond to those of man, there is a very powerful strong muscle, called the retractor, immediately at the back of the eye, which draws the eye further within the orbit. These muscles are all attached to the bony orbit and the sclerotic coat, and are furnished with nerves for the communication of motive power, as well as vessels for their nourishment. There is another peculiarity in the horse's eye which requires to be noticed, and that is the elastic cartilaginous substance called *membrana nictitans* or *haw*, the use of which is to act as an additional eyelid in wiping off extraneous particles from the surface of the eye. When the eye is drawn into the orbit by the retractor muscle, the haw is advanced over the eye from its elasticity, assisted by the pressure of the fat in which the eye is imbedded. The anterior portion of the eye is lubricated by the tears which are secreted by the lachrymal gland which is attached to the upper part of the orbit, the superfluous tears being conveyed through a duct to the nostrils. The eyelids are put in motion by distinct muscles.

Diseases of the eye.

The Diseases of the Eye are far less numerous than in the human subject, but are yet so serious that there are probably more blind horses than men in proportion to their relative numbers. *Ophthalmia* is of two kinds, simple and specific; the former, if properly and early attended to, ends in recovery; the latter generally terminates in blindness after a succession of attacks. *Simple ophthalmia* proceeds from external injury, such as blows, scratches, or hay seed, or other objects getting into the eye. The inflammation is generally considerable, with swelling and closing of the lids, superabundance of tears, and considerable cloudiness of the cornea and aqueous humour; the superficial inflammation is greater, and there is more opacity of the cornea than in—

Simple ophthalmia.

*Specific Ophthalmia*, which appears to arise from constitutional causes, engendered by stimulating food, hot stables, the escape of ammonia from the urine, and the hereditary predisposition of the animal, derived from its sire or dam. The *symptoms* very much resemble those of simple ophthalmia, but there is less external inflammation and opacity of the cornea, and more derangement in the interior, in the iris, the crystalline lens, and the vitreous humour. In very bad cases all these parts may be simultaneously affected, and blindness may soon follow; but the inflammation is generally more limited, attacking most frequently the crystalline lens and its capsule. When this is the case, the irritation is less than when the iris is principally affected. There is a great impatience of light, and on exposure to it, the pupil is soon closed. After some time the inflammation subsides, even if nothing is done, to be again renewed at another time; and in proportion to the duration, extent, and intensity of the attack is the disorganization that remains. From the periodical character of the disease, it has been absurdly supposed by the ignorant to have some connection with the changes of the moon, and thence it has been termed moon blindness; but though sometimes the attacks may return in about a month, the intervals are generally much longer. It is very important to ascertain, on purchasing a horse, if he has had any attack of ophthalmia; this cannot, however, always be done, for sometimes, with timely treatment, there has been no visible alteration of the structure left. But if we observe any dimness in the aqueous humour, cloudiness in the interior, specks or opacity of the crystalline lens, or unusual smallness of the pupil compared with the other eye, we may justly conclude that the horse has had one or more attacks of specific ophthalmia, which are likely to recur; whereas if there are only streaks across the cornea, or partial opacity of it, and the interior of the eye is bright and healthy, we may conclude that these appearances are to be attributed to simple ophthalmia, which is not likely to return.

Specific ophthalmia.

The *Treatment* of both diseases should be for the most part the same. If the attack is severe, we should commence by bleeding from the jugular vein on the same side as the affected eye, and follow this on the same or the following day by local bleeding from the angular veins, and lancing the eyelids. A dose of physic should be given, the eye frequently fomented with warm water, and the following lotion afterwards applied:—

| | |
|---|---|
| Tincture of opium . . . . | 2 drs. |
| Extract of belladonna . . . | 1 dr. |
| Water, pure or distilled . . . | 1 pint |

Mix.

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Veterinary Art. Cataract. *Cataract* is the usual sequel of ophthalmia, but sometimes it arises without any previous inflammation; and when small and only semi-opaque, appearing rather to affect the capsule than the body of the lens, it often disappears.

Amaurosis. *Amaurosis*, or *Gutta Serena*, is paralysis of the optic nerve, and is attended with partial, or more frequently total, blindness; the eye retaining its brightness, but the iris no longer acting from the stimulus of light. The cure is uncertain and doubtful, but may be attempted by bleeding, purging, and the exhibition of calomel and opium, a drachm of each daily. This disease may arise from blows, injuries of the brain, constitutional derangement, or from causes unknown.

Diseases of the mouth. Diseases of the Mouth.—*Lampas* is a term commonly given to a swelling of the bars at the upper part of the mouth. It is most common with young horses, and is frequently connected with the process of dentition. Unless it interferes with mastication, it is as well to let it alone; if otherwise, it may be lanced, or removed with a hot iron. It is often accompanied by a swelling of the gums and membrane between the molar and incisor teeth, and which, from getting between the teeth, is more frequently the cause of defective mastication than the lampas. It should be removed by taking it up with a forceps or crook, and cutting off a portion with a pair of scissors or a knife. Sometimes the teeth are found irregular, so as to injure the gums; when this is the case the irregular edges should be removed with a tooth-rasp, made expressly for the purpose. The gums are frequently injured by the bit: when this is the case, the following wash will be found the most suitable:—

| | |
|---|---|
| Alum | 2 drs. |
| Tincture of myrrh | 1 oz. |
| Honey | 1 ,, |
| Water | 2 ozs. |

Mix.

Sometimes the bone is greatly injured, and an ulcer is the consequence, the nature of which is ascertained by the very offensive smell that is present. In this case two drachms of hydrochloric acid, mixed with one ounce of tincture of myrrh, should be applied to the ulcer alone on a little tow. This will probably hurry the process of exfoliation, if the injury is sufficient to produce it, and a portion of the bone will be separated from the other part, and may be removed with a forceps; after which, with the application of the lotion, the jaw will soon get well. Other injuries of the mouth and tongue should be treated in a similar manner, viz., by the application of the lotion previously advised.

Injuries of the tongue. Sometimes the tongue is cut asunder by the halter being placed upon it, the horse's head being then tied up, and the animal in this state hanging back. This injury may also be produced by other means originating in the carelessness or brutality of the attendant. If the tongue is not more than half severed, the divided portions may be united by sutures; but if it is nearly or quite cut asunder, the bleeding vessels should be tied, and the part dressed with the above lotion; and though the horse must be kept on gruel and mashes for some time, it is astonishing how well the mutilated tongue will become adapted to perform its functions, so that corn and hay will be consumed as well as before; but it will not be advisable to turn the horse to grass, as he will not be able to gather the grass either so fast or so well as before.

Obstructions in the œsophagus. Obstructions in the Œsophagus sometimes arise either from a hard ball getting across, or a piece of carrot or turnip, or other food being hastily swallowed without being properly masticated. If the obstruction lie in the throat, it may often be removed by the hand; but if it cannot be reached, an instrument called a probang, consisting of a long piece of whalebone, with a handle at one end and a ball of wood at the other, should be carefully passed down the œsophagus, so as to force into the stomach the obstructing body. Or if the obstruction is near the throat, it may be withdrawn by means of a suitable probang. If the object cannot be removed by these methods, we must then have recourse to the operation of *œsophagotomy*. The horse's head being elevated, a careful incision must be made through the skin and the coats of the œsophagus, sufficiently large to permit the removal of the obstructing body. The wounds both in the œsophagus and the skin should afterwards be united by separate stitches, and kept clean. No food should be allowed for many hours afterwards; and it should then be given in a soft state.

Structure of the foot. The Foot of the Horse is an admirable piece of mechanism, but so complicated and minute is its construction that our space will only permit us to mention its various parts, which may be seen in the plates of the horse which accompany the present work; and we must refer the reader who desires more extended information to Spooner's Treatise on the Foot and Leg of the Horse, and other works on the subject. When the foot is on the ground, all that we see externally, is the *wall* or *crust*, which is the strongest part, and bears the weight of the animal. It is attached to the coffin-bone within by means of certain horny leaves or *laminæ*, 500 in number, on its inner surface, which dove-tail with corresponding fleshy plates on the coffin-bone. The lower part of the foot is concave, and is, for the most part, formed by the *sole*: it is incapable of supporting much weight, or pressure, with impunity; thus the shoe is nailed to the crust above, and occasions lameness, if it presses on the sole. The *bars* appear to be inflections of the crust, and meet the frog, which is formed of softer and more elastic horn than the other parts, and acts like a wedge in preventing slipping. The bars and crust are secreted by the laminæ, and the vascular material at the coronet called the *coronary substance*; the sole and frog are secreted by the sensible sole and frog immediately above them, the former being firmly attached to the lower part of the coffin-bone, the latter to the elastic cushion which forms and fills up the back part of the hoof. The coffin-bone, or *os pedis*, corresponds in shape to the hoof which surrounds it, but does not extend so far back, particularly in the middle part: it has cartilages attached to its wings, which extend above the hoof, and sometimes become ossified. At its posterior and central part we find the *navicular* or shuttle-bone, the upper part of which forms, with the coffin-bone in front, and the small pastern above, the coffin-joint, whilst its posterior and lower surface forms the navicular-joint capsule, over which the flexor tendon glides like a pulley just previous to its insertion into the lower part of the coffin-bone. It is this joint capsule which is the seat of the navicular disease, the frequent cause of lameness. The small pastern, or *os coronæ*, is a short, thick, strong bone; above which is



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the *os suffraginis*, or large pastern, a longer bone articulating with the metacarpal bone above, and forming the fetlock joint. This important joint is protected on the back by two small bones, the *sesamoids*, which bear a portion of the weight, and are suspended above by the elastic suspensory ligament, thus forming a beautiful spring. The *suspensory* ligament, which becomes double half way down the shank, is attached to the metacarpal bone above, and passes down between this bone and the flexor tendons. The most posterior of these tendons, called the *perforatus*, forms a sheath for the other, the *perforans*, just above the fetlock; which sheath continues half way down the pasterns, where the perforatus is inserted into the small pastern, and the perforans continues on at the back of the navicular bone to be inserted into the lower part of the coffin-bone as before observed. The above brief notice will be better understood by reference to the plates, and our space forbids any further description of these beautiful and complicated organs.

On shoeing.

The Art of Shoeing is extremely ancient, and though not adopted in all countries, it is particularly called for on our hard roads, where the use of the horse would be extremely limited without it. It is a necessary evil, inasmuch as it consists in nailing an inflexible rim of iron to the elastic, though insensible hoof. The subject is one of too great extent to prosecute at any length in our limited space; we must therefore refer to more elaborate treatises, and content ourselves with mentioning certain principles by which it ought to be regulated. It would, however, be folly to attempt to establish any invariable rules, either for the preparation of the foot or the manufacture or putting on of the shoe further than this, that in no case ought the shoe to rest on the sole of the foot, but on the lower edge of the crust alone. The thickness, strength, elasticity, and dryness of the horn vary considerably in different horses; but taking, for example, a foot that possesses an average amount of these qualities, we may observe, that as the shoe prevents the sole and frog from being worn down to the same amount as they grow, as would be at least the case if the foot was unshod, a certain portion requires to be pared with the drawing-knife at each time of shoeing; but in general this paring should be limited to the ragged parts of the frog and the dry portions of the sole. Some of the crust also requires to be lowered, particularly towards the toe and heels; but if the foot is weak and thin, the latter should be held sacred, and the other parts of the foot merely cleaned or scraped out: the sole lying between the crust and the bars at the heels should however be pared out, particularly if there be any disposition to corns. The shoes must be heavy or light in proportion to the size, work, and wear of the horse. It should be made to last, if possible, three weeks; but if not worn out in a month, it ought to be removed, in order that the foot may be properly pared out. The shoe on the fore-foot should generally be of equal thickness throughout, seated on the inner part of the foot surface, and flat on the ground surface, about an inch in width, and one-third of an inch in thickness for saddle horses, and fastened on with eight nails, the back one on the inside being as far removed from the heel as the security of the shoe permits. The hind shoes must be thicker and narrower than the front ones, and rounded off on the inside so as to prevent cutting. The *leather sole* is an excellent addition to the shoe for horses that travel on the road, and in the summer season particularly. It diminishes concussion, protects the horn from too much wear, and preserves the sole soft and elastic by means of the stopping of tar, grease, &c., which is secured by tow between the foot and the leather. There are a variety of shoes adapted to particular feet, and particular circumstances, which cannot well be explained without figures, and can be better understood by visiting the forge of a veterinary surgeon, where may be seen shoes adapted for hunters, others for saddle horses, wider and stouter ones for carriage horses, and heavier shoes still for waggon horses, often turned up at the heels to form calkins for the hinder feet with advantage, but which never ought to be done with the fore shoes. There also may be seen shoes for *cutting*, some thick on the inside, others thicker on the outside, and all *feather-edged*, as it is termed, on the inside. Shoes likewise for corns, with the inner heel made thin, so as not to rest on the ground, and *bar shoes* also for the same purposes. It need not be observed, that the proper shoeing of light horses requires considerable care and skill; and it is a false economy that, to save expense, would be satisfied with inferior workmanship. Two men are usually employed about a horse at the same time—one who fits the shoe, and another who nails it on; the latter perhaps requires to exercise the most care, and the former the greatest skill. Both operations can be much better performed in the forge than the stable, and the feet should invariably be stopped with cow-dung or linseed meal the previous night. This stopping should be used indeed every night in dry weather to the fore feet, and several times a-week otherwise. Dry brittle feet will also be greatly benefited by being occasionally anointed with one part of oil of tar mixed with two or three portions of linseed oil.

On lameness.

*Lameness* is the natural language of pain, immediately arising from the unequal action of the limb; the horse bearing as lightly as he possibly can on the injured leg. It may exist in every variety, from the severe manifestation of acute pain to the slightest exhibition of partial tenderness. In very acute lameness, most people can point out the suffering limb; but in those of a less severe character, the utmost tact is often required. Persons unaccustomed to horses will more frequently pronounce the wrong limb than the right, in cases of slight lameness. They perceive that a horse drops the moment one foot comes to the ground, and they immediately conclude that that must be the lame one, fancying that he flinches from the pain received when it meets the ground, whereas the fact is, he treads as lightly as he can on the lame foot, and drops with his whole weight on the sound one. In shoulder lameness we can generally ascertain the seat of mischief by the slow and laboured extension of the limb, which is more evident in going down a declivity, and likewise in the walk more than any other pace, the horse having in slow motion more time to move the limb with the care that he wishes. In severe lameness from splints, there is often an unwillingness to bend the knee exhibited; this however is also shown in cases of slight strains of the sinews just under the knee. With these exceptions, the seat of disease, whether of the foot, the pasterns, or the fetlock, cannot be ascertained by the nature of the horse's action. In examining a lame horse, it is desirable in the first place to see him undisturbed in the stable, and observe whether he *points* a foot, and in what particular manner he so favours it.

Mode of detecting the seat of lameness.

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He should then be trotted gently in hand on the hard road or pavement, giving him his head at the time. Having thus ascertained the leg he is lame in, we should proceed to discover the actual seat of the mischief. For this purpose, the finger and thumb should be carefully passed down the leg from the knee to the foot, to ascertain if there is any undue heat, or enlargement, or tenderness from pressure; we should also feel carefully the front and sides of the pasterns, as well as round the coronet. If a splint be the cause of lameness, the horse will evince considerable pain when it is pressed, and so likewise will he in lesions of the sinews. Supposing that we have found no sufficient cause of lameness above, we must now direct our attention to the foot. In nearly every case, unless the mischief should be very clearly exhibited elsewhere, it will be advisable to remove the shoe; the foot should then be pared out to ascertain if there be any wound or bruise in it. The nail-holes and the heels of the sole should be carefully examined and pressed with the pincers, or gently struck with a hammer to discover any symptoms of tenderness. If the horse is very lame from a corn, he will almost always favour the foot, by elevating the heel without extending the foot very far, which will give a knuckling appearance to the limb. Should none of these symptoms be exhibited, we must consider the disease to be deeper seated, and then it is all-important to ascertain if the animal points his foot, for if such be the case, in all probability the cause of lameness exists in the navicular joint.

**Lameness connected with shoeing.**

*Lameness connected with Shoeing.*—Horses sometimes exhibit a slight lameness immediately after being shod, though quite sound before. Such cases may arise from the shoe being nailed on too tight, and is often relieved by removing the shoe, and re-applying it more gently. This lameness most frequently occurs in horses with very thin horn, and is ascertained by the manner in which it comes on, and the absence of any other visible causes. The shoe may have an improper bearing, pressing severely on weak parts, or on the sole or heels. *Pricks* most frequently arise from careless or bungling workmanship, the smith not taking proper care, or being deficient in proper skill, or rendered foolhardy by partial drunkenness. Occasionally, however, it will happen with the utmost care, either from unsteadiness of the horse, a particularly thin horn, or perhaps the deceptive appearance of the foot. After a few days, lameness manifests itself, either slight or very severe, and on removing the shoe, and pressing round the foot at the situation of the nails, considerable pain is evinced at the seat of the mischief; and on cutting down on the nail-hole, matter very frequently issues. Sometimes, however, there is no matter formed, but a thin acrid fluid, which denotes that much inflammation still exists in the part, and then the lameness is commonly more severe. In either case it will be desirable to remove the surrounding horn, and immerse the foot in a warm poultice, which should be continued until much of the tenderness is removed, and the parts present a healthy appearance, when the application of a stimulating tar ointment will effect a cure, care being taken that the shoe does not bear too near the injured part.

Sometimes, on removing the shoe, there is no matter found, and indeed no wound, although considerable tenderness. In these cases the nails have been driven too near the quick, although they have not actually penetrated it. The lameness does not come on immediately after the application of the shoe, not indeed until the repeated force of the animal's weight has forced the edge of the coffin-bone so close to the nails as to bruise the sensible parts between these two hard bodies. The best treatment consists in the removal of the shoe and the application of poultices.

**Corns**

*Corns*, in most cases, are produced either directly or indirectly by shoeing; directly, when the heel of the shoe actually presses on the heel of the horny sole, and indirectly, when it bears too hard on the crust, or prevents the performance of the functions of the foot. A corn in the horse is a bruise of the sensible sole in the angle between the bar and crust; extravasated blood is thrown out, and this being repeated, at length the vessels of the part, instead of secreting sound horn, deposit a soft spongy material, tinged with blood. Sometimes matter is formed, and at other times we find a black discharge. Corns, though found in all kinds, are most common with flat weak feet having low heels; and they are rarely found in the hind feet or the outside heel. If relief is not afforded, by making an exit below, the matter soon extends upwards and breaks out between hair and hoof, and proves very troublesome. The method of *treatment* for a slight corn consists in cutting away the horn almost to the quick, and applying some caustic, such as the muriate of antimony, to the part. In more severe cases, a poultice should first be applied for several days. A shoe should be put on with the bearing taken away from the affected heel, and the nails removed from the neighbourhood. With flat feet, a bar shoe will best enable the pressure to be removed; with others, a shoe with the ground surface of the affected heel seated off, so that the heel of the shoe does not press on the ground, will best answer the intended purpose. If matter breaks out at the coronet, a large depending opening should be made, the foot well poulticed, and a strong solution of sulphate of zinc injected with a syringe. In some cases the horn should be removed from the coronet to the heel. The treatment here recommended will apply to most other injuries of the feet, such as bruises, wounds from nails, &c.; but if the latter case is severe, blood should be taken from the affected limb.

**Quittor.**

*Quittor* is a disease somewhat resembling a festered corn, but it is more deeply seated, having for its locality the lateral cartilages of the foot, in and around which sinuses are formed; and it usually arises from a tread either from the other foot or from another horse. In consequence of the cartilage being injured, the cure is often very tedious, and does not take place till a portion of the cartilage exfoliates. It is expedient to get a good free external opening, and after the foot has been well poulticed, to inject a strong solution of sulphate of zinc. This treatment will often effect a cure, but sometimes it is necessary to insert one or more setons, bringing them out between the bars and the frog. In others a slough may be produced by forcing some oxymuriate of mercury into the sinuses, which will cause a portion of the cartilage to exfoliate; after which the part will heal with ordinary applications. Severe treads should be treated by poulticing and afterwards applying the solution of sulphate of zinc.

**Sandcrack.**

*Sandcrack* is a fracture or split in the hoof, which, when it penetrates to the quick, occasions lameness. Its usual seat is the inside quarter of the fore and the front

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part of the hind foot. Poultices should be applied for a few days, and as soon as there is sufficient sound horn above the crack, a transverse line should be made with a firing-iron or drawing-knife above the crack, and a strap applied round the hoof, and in time the foot will grow down sound, and the crack disappear.

Thrush.

*Thrush* is a common and offensive discharge from the cleft of the frog principally, but sometimes affecting other portions of the frog, which appear, as it were, to be eaten away by the acrid discharge. Though thrush seldom occasions lameness, it renders the frog tender; and when the horse treads on a stone, there is great danger of falling; and if neglected, thrush is apt to degenerate into canker. The ragged parts of the frog should be pared off; and a pledget of tow dipped in the following ointment, and renewed every second day, will usually effect a cure.

| | |
|---|---|
| Barbadoes tar . . . . . | 4 ozs. |
| Sulphuric acid . . . . . | ½ oz. |

Mix.

Canker.

*Canker* may be produced either by thrush or grease, and sometimes by neglected injuries of the foot. Though it usually commences with the frog, it spreads to the bars, sole, and crust; and when very extensive, it is often incurable. Instead of sound horn, a fungous substance is secreted, together with an offensive discharge, and it is extremely difficult to get the horn to form again, particularly where one part joins another, as between bar and frog. Slight cases may be treated like thrush, but in severe ones the fungus should first be removed by the knife or caustic, and then either the ointment recommended for canker should be applied, or a powder composed of chloride of lime, alum, and prepared chalk. In some cases nitric acid, either alone or with tar, makes the best application. Moderate pressure is extremely desirable, and if the horse can be slightly worked on a dry surface, it will expedite the cure. Moisture must by all means be avoided. If the canker proceeds from injury, and affects the crust, it will be very desirable to remove every portion of the horn that is in the slightest degree connected with the disease. In this way the writer has, after some time, succeeded in curing canker so extensive that one-half of the crust, sole, bars, and frog has been removed and renewed.

Laminitis.

*Laminitis* or *Founder* is, as its name implies, an inflammation of the sensible laminæ of the foot, as well as the elastic and very vascular substance that connects with these laminæ the coffin-bone. Horses with weak feet are most disposed to this disease, both in its acute and chronic form. In acute laminitis there is considerable pain and irritation, the pulse strong and quick, the respiration quickened from pain, and the feet hot; the horse is excessively lame, and almost constantly lies down. The last symptom is strongly marked, and serves to distinguish it from other acute diseases. The causes are, long-continued and rapid exertion on the hard roads in hot weather, confinement in a standing posture for a long period, and what is called *Metastasis*; that is, the sudden removal of inflammation from another part; and thus this disease often supervenes on an attack of pleurisy or rheumatism of the chest (a chill). The last cause is perhaps the most frequent and the most likely to be attended with permanent derangement in the structure of the foot. The *treatment* of this disease must be prompt and energetic, and the first thing which demands attention is copious blood-letting. The shoes should be taken off, the soles pared thin, and the circular artery opened by cutting through the horn between the toe and the point of the frog until the blood appears in a free and copious stream and of a red colour. The blood should be abstracted from both feet, if both are affected, and it may be assisted by immersing them in warm water. The bleeding should continue until the system appears to be affected by it: from six to seven quarts will not be too much to abstract. If the horse cannot be readily or freely bled from the feet, the brachial or plate vein at the arm may be selected; but the toe is preferable, being so much nearer the affected parts. After bleeding, the feet should be put in linseed-meal poultices, which should be repeated daily and continued for some time, the feet being also fomented with warm water several times a-day. Unless there is very evident improvement on the second day, bleeding may be repeated, and from the arm. After a few days a blister should be rubbed on the coronet, which should be fomented the following day, so as to remove the effect of the blister, which should be thus repeated several times. Chronic laminitis may be treated in the same manner; the bleeding, however, being practised with less severity. The most favourable termination of laminitis is resolution, in which the inflammation soon subsides, and the parts are restored to their former state. Another result is the separation of the coffin-bone from the crust, the space being filled up with horny substance instead of laminæ, and the sinking of the sole. This is called a pumiced foot, and the horse becomes permanently lame, and fit only for very slow work.

*Pumiced* feet, however, sometimes arise from weakness of the horn of the foot; and when this is the case, by careful shoeing, so as to protect, and at the same time not to press on the sole, the animal is enabled to do a good deal of work. A blister to the coronet will encourage the growth of horn, and the application of tar to the foot, and a bar shoe, and sometimes a leather sole will be very serviceable. A *seedy toe*, which sometimes accompanies the last-mentioned disease, is a separation of the outer from the inner layer of the crust, which thus appears hollow from the toe almost to the coronet, and at length no longer affords any hold for the nails. The only remedy is blistering the coronet and rest, so as to give time for a new hoof to grow down from the coronet. The disease may be attributed to too great dryness of the foot, want of tone in the secretive parts, and the destructive action of the nails of the shoe.

Strains.

*Strain* or *Sprain*, frequently the cause of lameness, is a violent extension of the fibres of a part, causing inflammation either more or less severe, with its attending pain, lameness, swelling, and heat. Strains of the muscles are much less frequent than of the tendons, and, though accompanied with greater pain and lameness, more frequently recover. Strains of the muscles of the shoulder sometimes arise from a slip or other extension, and may be distinguished by noticing that the lame leg is not extended so far as the sound one; that the lameness is very evident in the walk, as well as the trot; is greatest on going down hill; and on elevating the leg and pulling it forwards, great tenderness is evinced. *Treatment.*—Bleeding from the arm, fomenting the shoulders, and afterwards applying a liquid blister.

Strains of the shoulders.

*Strain of the Flexor Sinews* is a frequent case, and is attended with heat, swelling of the part, and pain

Strain of the flexor sinews.

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**Firing.**

when pressed. *Treatment.*—Bleeding from the arm, fomentations, and cold lotions to the leg; and when the inflammation is removed, blistering the leg; or if there is evident thickening, what is still better, *Firing.** In severe cases a patten shoe, so as to elevate the heel of the affected leg and put the tendons in a state of rest, will be found useful. The following lotion will be the most effectual:—

| | |
|---|---|
| Sal ammoniac . . . . . . | 1 oz. |
| Arabic acid . . . . . . | 2 ozs. |
| Spirits of wine . . . . . | 1 oz. |
| Cold water . . . . . . . | 20 ozs. |

Mix.

**Strain of the suspensory ligament.**

*Strain of the Suspensory* ligament is nearly as common as that of the tendons; the lameness, though less severe, is often more obstinate. The part is hot, swollen, and tender on pressure. The treatment should be the same as that just advised, and the firing is particularly required; and, if performed, by making punctures so as to penetrate the skin, it will be more effectual. Strains of the ligaments of the fetlock joint should be treated in a similar manner; and so likewise with regard to the pastern joint, which is often the forerunner of ringbones. *Strains* of the ligaments of the *coffin-joint* are rare, the joint being so securely situated. When occurring, however, bleeding from the foot, poulticing, and blistering the coronet will be the proper treatment.

**The navicular disease.**

The *Navicular disease* is one of the most frequent lamenesses with which the horse is affected. It consists of inflammation and ulceration of the navicular joint capsule. The navicular bone is generally denuded of cartilage, with small bony excrescences, and sometimes ulcerated holes on its posterior surface, and occasionally adheres to the sinew. The symptoms of this disease are, lameness, greatest at first and diminishing with exercise; the absence of all cause of lameness elsewhere; contraction of the foot; thickening and elevation of the sole, and pointing; that is, the foot is put out several feet beyond the other, and bears no weight: the foot and coronet rarely feel hot, unless the lameness is sudden and very severe. Confinement in the stable, hot litter, shoeing, and particularly the hard roads, may be considered as the causes of this disease. It is very frequently incurable, ulceration having commenced; but the following *treatment* may be tried, which has occasionally proved successful. The sole should be pared thin, the quarters well rasped, the feet bled and poulticed; and then the coronets blistered, or a seton inserted through the heel and the cleft of the frog, and kept in for a month. If this treatment should fail, and the horse is too lame to be useful, the only resource left is—

**Neurotomy.**

*Neurotomy*, or the nerve operation. The horse having been cast or thrown by means of the hobbles, the foot to be operated on should be liberated, and drawn out straight, and an incision made through the skin a few inches above the fetlock, and between the flexor sinews and the suspensory ligament. In this space the nerve will be found, on removing some of the cellular membrane, somewhat behind the artery on the inside, and posterior to the vein on the outside of the leg. A little thread should be carried under the nerve, which should be drawn up, and divided at the upper part of the incision, and an inch and a half of it excised. The horse is then to be turned, and the operation repeated on the other side of the leg. The leg should be previously rendered perfectly cool, by immersing it in a bucket of cold water for half an hour at a time, so as to prevent bleeding from the small vessels, which would render the operation difficult and tedious. The object and immediate effect of the operation is to remove pain, and consequently lameness, by cutting off sensation between the diseased part and the brain. There being no muscles below the knee, the nerves only communicate feeling, and by dividing them, pain is of course removed with sensation, and by removing a portion of some extent the reunion of the nerves is prevented. The operation has succeeded in very many instances, and the horses have worked for some years afterwards. It is generally performed above, but sometimes on or below, the fetlock; the effect of the latter mode is to afford some degree of feeling to the foot, as the branches that supply the coronet are given off above the seat of the operation. The wounds after the operation should be bandaged, and treated as an ordinary wound. The horse should not be turned to grass, but may be put to moderate work, in the course of six weeks or two months after the operation. It is evident that the effect of the operation is to remove the lameness, but not the disease which produces it; this should be borne in mind, and the horse should be employed afterwards in moderate work alone. When this is not observed, and the horse is hunted or otherwise worked violently, or allowed to gallop at grass, the diseased sinew, which the disease had rendered thinner, and fixed to the bone, sometimes snaps asunder, the toe of the foot turns up, and the horse is rendered useless. In proper cases, it is a valuable and humane operation, and reflects great credit on Professor Sewell, by whom it was introduced.

**Exostosis.**

Exostosis is a diseased enlargement of bone, from an increased action of the vessels by which it is nourished, and usually arises from inflammation produced by strain or concussion: horses are very subject to this disease, which under the terms splint, ringbone, spavin, &c., are frequently the cause of lameness.

**Splint.**

*Splint* or *Splent*—is a bony deposit, situated between the large and small metacarpal bones, generally on the inside of the leg, and a few inches from the knee. Most horses are subject to it when about four or five years old, and in the majority of instances it is not attended with lameness. In some instances, however, there is severe, and in others slight lameness, which appears to arise from the state of tension in which the periosteum, or membrane covering the bone, is placed, by the increased deposition beneath it. In those cases, unattended with lameness, the growth of bone is so gradu-

* The operation of Firing, though severe, is often necessary, and succeeds in many cases in which milder methods have failed. It should not, however, be practised when less severe remedies will succeed. The method of performing it is simple, though requiring some tact and care. The horse having been cast, the leg to be operated on must be sufficiently liberated to expose properly the affected part, on which lines about half an inch apart should be drawn by means of irons, with a moderately sharp edge, and heated to a red heat. An oblique direction is the most convenient, and the degree of heat to be applied must depend on the thickness of the skin and the nature of the case. In general it should not penetrate the cutis, but should be continued until the line it causes is of a brown colour. Its action may be increased if necessary by making punctures through the skin with a pointed iron; and in some cases the firing may be limited to these punctures with advantage, as producing a deep-seated effect with little blemish.

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that its covering has time to accommodate itself to the increased size. When lameness proceeds from splents, pressing them occasions considerable pain. *Treatment.*—In very slight cases a little blistering application on the seat of the splent will be sufficient, but in severe cases, the best mode of treatment consists in the operation of *periosteotomy*. The horse must be cast, and an incision made at the lower part of the splent, one-third of an inch in length, and a small narrow knife, blunt pointed—made for the purpose—must then be passed up under the skin, the whole length of the splent, and the periosteum must be divided by pressing it up and down. A small opening being made above, a seton may be inserted and kept in for a fortnight. The effect of the operation is to remove the tension of the periosteum, which puts a stop to the inflammatory action and the lameness.

Periosteotomy.

Spavin.

*Spavin* is a much more serious evil than a splent: it is perhaps in nine cases out of ten attended with lameness, which in the majority of instances is incurable. Its situation is the inside of the hock, on the small bones of the joint, which are frequently anchylosed, or connected together permanently by a bony substance, and the synovial membrane and cartilage are often in a state of ulceration. This state of the joint sometimes exists either in the upper or one of the lower articulations of the hock, and then the lameness is very obscure, and often incurable. *Treatment.*—If there is heat perceptible in the hock, blood should be taken from the saphena vein, which passes up on the inside of the thigh, and the inflammation reduced by cooling lotions; after which the part should be repeatedly blistered with the iodide of mercury ointment, mixed with the common blister; or the horse may be fired. Some incurable cases have been relieved by excising the nerves above, and on the inside of the hock.

*Wind-galls* are soft swellings existing near the fetlock joints, either formed by the distension of the capsular ligament, or the sheaths of the tendons with synovial fluid; sometimes there is a rupture of the connections of the sheath, and a consequent enlargement of the cavity. They rarely occasion lameness.

*Bog-Spavin* and *Thorough-Pin* are similar in their nature to wind-galls. The former is found at the lower and anterior part of the hock-joint, and the latter at the upper and back part of the same cavity. The best treatment of these enlargements is the application of the iodide of mercury ointment, which should be well rubbed into the part, and renewed once a-week, washing off the effects of the previous application in the interval.

Ringbones.

*Ringbones* are bony formations on the pasterns, arising from strains of the ligaments or concussion. The seat of disease may be detected by the enlargement, which is generally attended with heat. The *treatment* should be the same as that recommended for spavins, and is generally attended with greater success.

False ringbones.

*False Ringbones* are ossification of the side cartilages of the foot, and usually proceed from concussion. Heavy draught horses are most liable to this disease, which is not so usually attended with lameness as the true ringbone, to which the treatment should be similar. This disease sometimes accompanies that of the navicular joint. When the usual treatment fails, the nerve operation should be employed. Exostosis sometimes occurs round the fetlock and other joints, and should be treated as before advised.

Fractures.

Fractures are not so common in the horse as in the human subject, and are generally treated with less success. This arises from the great displacement of the bones from walking on them after the fracture, the difficulty in keeping the horse in a quiet state, the want of the recumbent posture, and the displacement of the bones from muscular action. Fractures of the upper parts of the limbs are therefore scarcely ever attended with success, and the most prudent plan in such cases will generally be to destroy the horse. Fractures of the bones below the knee are, however, not unfrequently cured; very much depends on the disposition of the animal, whether he is quiet, or irritable and fractious; in the latter instance, the chance of cure is but slight; and it must be confessed, that in successful cases, much more depends on nature than on surgical skill. The parts being carefully bandaged, and kept wet and cool, will in many cases be as successful as more laboured treatment.

Dislocations.

Dislocations are, from the little lateral motion the joints possess in the horse, still rarer than fractures: they can scarcely occur without a rupture of the ligaments. Dislocation of the patella or knee-pan, which is situated at the stifle-joint, sometimes occurs, and mostly in young animals, and arises either from sudden and violent exertion, or from relaxation of the ligaments; when it takes place the animal is in much pain, cannot flex his hind leg, but drags it after him. The disease is often mistaken for cramp and other diseases. Sometimes, on alarming the horse, the patella will slip suddenly into its place; at others, this cannot be done without assistance. The foot should be drawn forwards with some force, and the bone pressed into its place, while the limb is thus extended; after which a blister should be applied over the part, and the animal kept perfectly still. Dislocation of the neck sometimes occurs from the horse being cast in his stall: the writer has had several cases in which he has succeeded in establishing a cure, by suspending the head, bandaging, splints, and anti-phlogistic treatment.

Dislocation of the patella.

Wounds.

Wounds.—The healing process in the horse is generally carried on with rapidity and vigour, particularly if the injury is confined to the muscles or flesh. A simple incised wound may be sewed up, but in a lacerated wound it is vain to attempt this method. Warm fomentations and cold lotions should be employed to abate the inflammation, and the wound may afterwards be dressed with tincture of myrrh or aloes, which will assist the healing process; or powdered resin may be scattered over the wound at first, and powdered chalk, alum, and Armenian bole afterwards. Bandages in some cases will be useful, in others not desirable. If matter forms, it will be essential that it should have a depending opening, which should be made and preserved by a seton. A wound of a joint, as the knee or fetlock, is entirely a different affair; the grand thing is to close the joint as quickly as possible before inflammation is set up in the cavity, which will quickly take place, unless the synovia or joint-oil is prevented from escaping, and the air from entering the joint. Poultices and fomentations on the wound are exceedingly injurious. If the opening is small, a hot pointed iron will often close the joint, or a paste of linseed-meal may be applied to the wound, and retained firmly by numerous bandages; this will generally be the most efficient method, and the inflammation, may then be kept down by local bleeding and fomentations without removing the bandages, which should be retained for some time.

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A saturated solution of bichloride of mercury, in spirits of wine, and applied to the wound by means of a feather several times a-day, has in many instances proved successful, and the following powder is also much to be recommended:—Burnt alum, myrrh, and sulphate of iron, equal parts, to be frequently applied to the wound. When the synovia has ceased to run, the injury may be treated as a common wound.

For a more extended acquaintance with the subject of this article, we must refer to the works of our Veterinary Anthors, amongst whom we may mention as the principal, the names of Coleman, Clark, Bracy Clark, Blaine, Darville, John Field, Goodwin, Morton, Percival, W. C. Spooner, Stewart, James Turner, and Youatt.

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